JOURNAL

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Contents

PAGE	
403	BEST SELLER
404	TELEVISION PICK-UP TUBES. PART I *by* PROFESSOR J. D. MCGEE, O.B.E., M.SC., PH.D.
411	ANNUAL GENERAL MEETING OF THE INSTITUTION
416	THE COMET CRASH
418	ANNUAL REPORT FOR 1954–55
438	ANNUAL ACCOUNTS FOR 1954
445	RADIO AIDS TO MARINE NAVIGATION
446	THE MEASUREMENT OF IRON LOSSES IN SHEET STEELS *by* PROFESSOR F. BRAILSFORD, PH.D., WH.SC.
448	MIXED THERMAL AND HYDRO-ELECTRIC GENERATION SYSTEMS
454	GERMANIUM *by* F. SZEKELY, B.SC.(ENG.)
458	HOME EVENTS
459	NEWS FROM ABROAD
461	THE RADIO SECTION DISCUSS DOMESTIC TELEVISION RECEIVERS
463	DIGESTS OF PAPERS IN THE *PROCEEDINGS*
480	CORRESPONDENCE
481	MONOGRAPHS AND PAPERS PUBLISHED SEPARATELY THIS MONTH
482	TECHNICAL PUBLICATIONS
483	LIBRARY ACCESSIONS
486	SOME RECENT BOOKS
488	ANNOUNCEMENTS TO MEMBERS
491	THE *JOURNAL* REFERENCE SECTION

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BEST SELLER

SEVENTY-THREE YEARS AGO THE ANNUAL REPORT OF the Council of the Society of Telegraph Engineers and of Electricians for 1882 contained the following paragraph:

> The already large and still increasing use of the Electric Light has naturally attracted the attention of the Fire Insurance Companies, who, in the absence of technical knowledge of the subject, were feeling considerable embarrassment in dealing with the insurance of buildings in which the light was installed; and the Council considered that it would be a public advantage that a series of rules should be drawn up for the guidance and instruction of those who have, or intend to have, the electric light installed in their premises, with the view of reducing to a minimum the risks of fire arising therefrom.

Thus was born the first edition of The Institution's Wiring Regulations under the title "Rules and Regulations for the Prevention of Fire Risks arising from Electric Light." It consisted of rather less than four octavo printed pages, as compared with the 200 pages of the 12th Edition.

At intervals of a few years the Regulations were revised and, keeping pace with advances in technique, succeeding editions grew in size as they became more complex and detailed. With the issue of the 5th Edition in 1907 the title "Wiring Rules" was used for the first time, and the value of the Regulations to the industry having by then become firmly established, the Council set up a standing committee to consider suggestions for amendment which any interested person or body might put forward. By this time observance of the Regulations had become widespread, the supply undertakings and the Fire Offices in particular giving them their support. Evidence of this trend, which continues unabated, may be found in the record of the number of copies sold of the various editions. Of the 6th Edition issued in 1911, 13 500 copies were distributed; more than 40 000 of the 10th Edition published in 1934; and well over 80 000 for the current edition, the 12th, published in 1950.

At the outset the principle was established that the views of industry and of the interests concerned should be obtained by inviting suggestions for revision and by including in the constitution of the Wiring Regulations Committee nominees of the interests concerned. In this way each successive edition prepared by the Committee and approved for publication by the Council represented the agreed views of all those affected.

At intervals there have been changes in the form and presentation of the Regulations, designed to keep them abreast of the times, and, as is well known, they were given official recognition in the Electricity Supply Regulations 1937, made by the Electricity Commissioners, and this recognition has continued to the present day.

The Wiring Regulations Committee have recently been engaged in the preparation of a 13th Edition of the "Regulations for the Electrical Equipment of Buildings," to use the present full title, which was first adopted for the 8th Edition in 1924. Before the drafting began, the Council, recognizing the important part likely to be played by the Central Authority and the Area Electricity Boards in administering the Wiring Regulations in practice, and their desire to continue to use them, took the opportunity of strengthening the Wiring Regulations Committee's liaison with the supply industry by inviting additional nominations from the Authority and Boards. These invitations were accepted, and the Committee also had the benefit of the Report of a Working Party set up within the supply industry to consider, both in general and with special regard to their legal implications, measures to ensure safety in electrical installations. In the result the 13th Edition marks a departure in presentation from its precursors, since it appears in two distinct sections. The regulations are so arranged that those in Part I must be met in a consumer's installation before, under the provisions of the Electricity Supply Regulations, 1937, a supply undertaking can be compelled to start, or in certain circumstances to continue, supplying energy to that consumer; the methods and practices which represent a means of meeting the requirements of Part I are described in Part II.

A few days ago the Council of The Institution authorized the publication of the 13th Edition and printing is now in hand. Notice of the availability of copies will be given in the *Journal* and the technical Press and it will be interesting to see whether this edition will achieve a success equal to that of its immediate forerunner, or, as seems not improbable from the figures quoted above, its sale will in fact be substantially greater.

Journal I.E.E., July 1955

An Electrical Engineering Review

TELEVISION PICK-UP TUBES

Part I. Physical Principles

Professor McGee, who was until recently with the E.M.I. Research Laboratories, discusses here the essentials of design of the modern television camera tube, as used for black-and-white television systems, and traces its evolution very briefly without dwelling on aspects of merely historic interest. Part II, in which the design and operating characteristics of the principal types of tube now in use are described, will appear in the August issue of the Journal.

Professor **J. D. McGEE, O.B.E., M.Sc., Ph.D.,**
Associate Member

1 Introduction

THE process of generating television signals in all modern television pick-up tubes may be divided into three main stages, as follows:

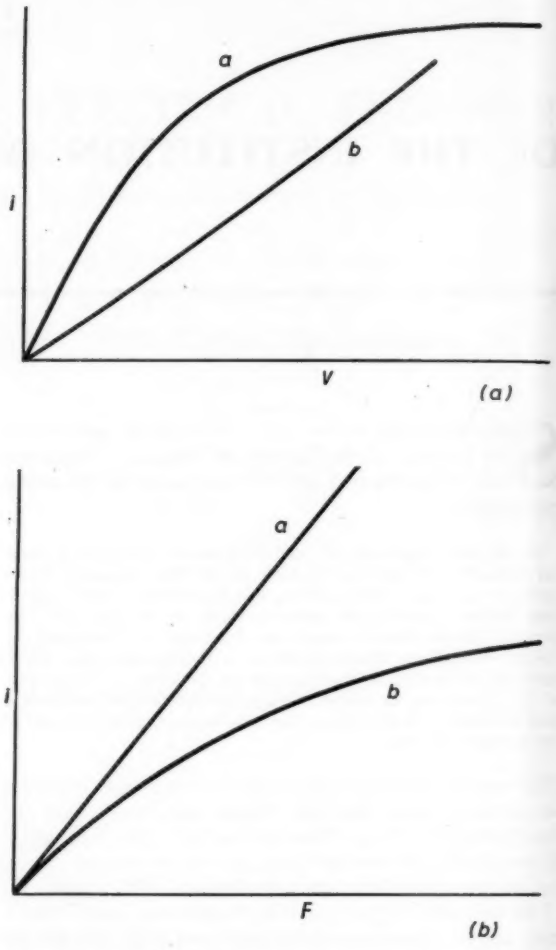
(i) The conversion of light quanta into free electrons liberated either from the surface of, or within, a solid body.

(ii) The integration of these free electrons, or charges produced by them, on a two-dimensional array of minute condensers during the picture frame-period of the television system.

(iii) The discharging in sequence (scanning) of these condensers in such a way that the stored charges produce the picture signal.

Each of these steps may be performed in several different ways and hence many combinations are possible, from which a feasible pick-up tube may be produced. Most, if not all, of these combinations have by this time been tried, and it is a fairly general conclusion that, while it is easy to design a pick-up tube to give television signals of a sort, it is very difficult to design one to give a marked improvement over those already available. However, all existing designs of pick-up tubes have more or less serious defects, and even the most sensitive falls far short of the fundamental limit imposed by the quantum process of conversion of light into free electrons. Improvement in the technique of any one of these steps, or of their combination, would result in a tube of improved performance.

In Part I of this review the essential features of the more important methods of carrying out the above three processes are described, and in Part II the methods of combining the processes will be illustrated by describing the design and operating characteristics of the main types of pick-up tube now in use.



1 *Emission or photo-current* **i**
(*a*) As a function of applied voltage.
(*b*) As a function of incident light flux.

2 Basic Processes: Photo-electric Effect

The first of the basic processes is the photo-electric effect, which, as its name implies, is the absorption of the energy ($W = h\nu$) of light quanta by electrons in matter, which thereby acquire sufficient energy to enable them to escape from their equilibrium energy levels and even escape from the surface of the solid in which the light is absorbed (the external photo-electric effect). Those that do not escape from the surface may become free to move within the solid itself (the internal photo-electric effect). This results in increased conductivity of the substance (the photoconductive effect), or a potential

difference may be set up between two layers (the photovoltaic effect).

External Photo-electric Effect

The main characteristics of the external photo-electric effect are that the number of electrons liberated is accurately proportional to the incident light energy, provided that the wavelength remains the same; the energy transferred to an electron by a light quantum is small—between 2 and 3 eV in the visible range—and a large part of this energy is lost by the photo-electron in escaping through the potential barrier of the surface of the material in which it is excited. Hence, most of the photo-electrons emerge from the surface, usually termed the photocathode, with very low energies—from about 1 eV to near zero. Few of these electrons will travel far from the surface unless an electric force is established to accelerate them towards a collecting electrode or anode. A field of about 10 volts/cm is usually sufficient to ensure the removal to the anode of all photo-electrons, which constitutes saturation. This is illustrated by curve (*a*) in Fig. 1(*a*), in which the ordinates represent the photo-electric emission *i* from a cathode to an anode as the voltage *V*, plotted as abscissae, is increased from zero. Above a certain value of *V* (determined by the shape and size or "geometry" of the tube) the photocurrent does not increase further; it is then said to be saturated. Under these conditions the relation between photo-current *i* and incident light flux *F* is, as shown by curve (*a*) in Fig. 1(*b*), a strictly linear relationship.

The photo-electrons may be liberated from the same side of a surface as that on which the light impinges and such a surface can be, and usually is, opaque. Alternatively the light may enter through one surface and the electrons emerge from the other; this type of surface must be transparent and is supported on a transparent supporting plate, such as glass. The former type is the more efficient by at least 50%, but the latter is so convenient in electron-optical devices, and the photo-electrons can therefore be used so much more efficiently, that it is in far more general use.

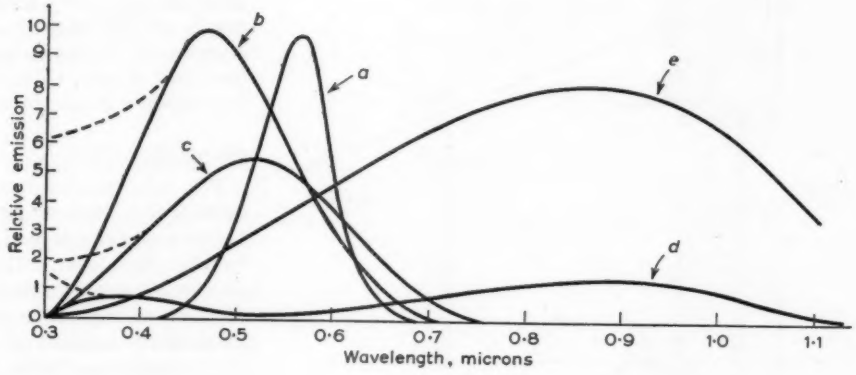
The photo-electric emission produced by a given amount of light energy is very dependent on the wavelength of the light employed. The curve showing the relationship between these quantities is known as the equal-energy colour-response curve and is a characteristic of the chemical and physical composition of the photo-electric surface. Typical curves for the main types of photocathodes are shown in Fig. 2. The three surfaces are:

Curve (*b*). Transparent antimony layer activated with caesium (Sb–Cs); U.S.A. type No. S.9.

Curve (*c*). Transparent bismuth-silver alloy layer activated with caesium (Bi–Ag–Cs); U.S.A. type No. S.10.

Curve (*d*). Transparent silver layer oxidized and activated with caesium (Ag–O–Cs); U.S.A. type No. S.1.

A similar curve for the response of the human eye, curve (*a*), is also shown, and it will be noted that it does not match very accurately that for any photocathode. If, however, the excessive response to blue light of the Bi–Ag–Cs cathode [curve (*c*)] is corrected by the use of a yellow filter, the resulting response can be a fairly close approximation to that of the eye. This is, of course, an important requirement in television used for entertainment purposes.



2 *Equal-energy colour-response curves*

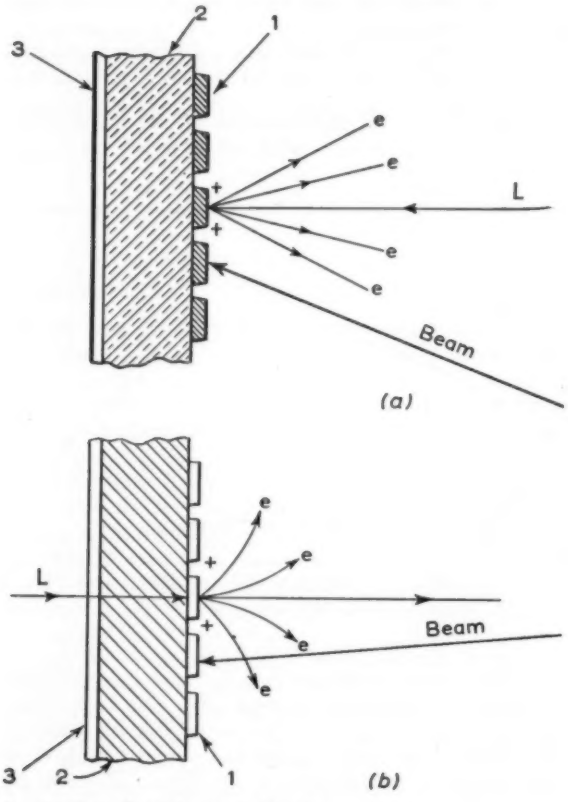
Owing to the dependence of the emission on the wavelength of the incident light it is necessary to define accurately the colour of a light source used for measuring photo-electric sensitivities. The standard is an incandescent tungsten lamp operated at 2875° K. The distribution of radiated light energy at different wavelengths from such a source is plotted as curve (*e*) in Fig. 2. It will be noted that the energy radiated per unit of wavelength is six times as great at the red end of the spectrum as at the violet end. In fact, it is a very red source of light. By contrast, in daylight the amount of energy per

unit wavelength is almost equal in the violet and the red.

If it is required to televise a subject illuminated mainly or entirely with infra-red light, the best photocathode to use is a Ag–O–Cs one [curve (*d*)]. If violet or ultra-violet light is to be used, then the Sb–Cs surface [curve (*b*)] is the most efficient, but a quartz window must be fitted to the tube.

Internal Photo-electric Effect

Light quanta absorbed by the electrons within certain materials produce an increase in conductivity. This effect, known as the *photoconductive effect*, can be utilized only by applying a potential difference across the layer, which will cause a greater current to flow where the layer is illuminated than where it is in darkness. The relationship between the current i that flows under the influence of a voltage V is much more complex than in the case of the external photo-electric effect, since the primary photo-electrons may produce secondary electrons, the number produced increasing with the applied voltage. Curve (*b*) in Fig. 1(*a*) is a fair example. Also, the characteristic photocurrent curve, for a given potential gradient across the layer, may vary between the values indicated by curves (*a*) and (*b*) in Fig. 1(*b*), depending on the photoconductive material used.



3 *Sections through mosaic targets*
(*a*) Opaque target.
(*b*) Transparent target.

The photoconductive effect is generally recognized as having a higher quantum efficiency than the external photo-electric effect. Figures as high as 100% have been quoted. This high efficiency, together with the secondary effects within the photoconductor, results in a photocurrent of several hundred microamperes per lumen of incident light. This attractive feature is offset to some extent by the undesirable time lag in the photo-conductive effect, which varies in duration from a fraction of a second to minutes; in no case is the effect substantially instantaneous, as is the photo-electric effect. The choice of materials for use in television pick-up tubes is limited, for reasons which will be made clear in Section 3, to those which have a high specific resistance in darkness. This reduces the possible materials to three or four, of which amorphous selenium and anti-mony trisulphide are the most useful.

The colour-response curves of photoconductive materials vary very widely and are dependent on the details of the method of preparation. However, the response of antimony trisulphide is not very different from that of curve (*b*) in Fig. 2, while selenium has rather less response in the red and more in the blue.

Photovoltaic Effect

The term photovoltaic is used to describe the pro-duction by incident light of an electromotive force between a metal layer and a semi-conductor separated by a blocking layer. This might be a copper-oxide layer on copper or a transparent gold layer sputtered on to a metallic selenium layer supported on a steel plate. The effect of the incident light is to establish the metal layer at a negative potential relative to the semi-conductor. This effect has been used in experimental television pick-up tubes but it is not employed in any contemporary tube.

3 Charge Image Integration

By whatever means the light is converted into electrical charges, these, or charges produced by them, must then be integrated as completely as possible throughout the picture frame period to form a replica, in distribution and intensity, of the original light image. The charges must be held on an array of minute condensers all of which have one plate, the *signal plate*, in common, so devised that they are accessible to the scanning (discharging) agent. The condensers must have sufficient insulation from the common electrode and from one another to prevent appreciable leakage during one frame period.

The Photosensitive Mosaic

The mosaic was used in the first successful pick-up

tubes; it is illustrated diagrammatically in Figs. 3(*a*) and 3(*b*). Fig. 3(*a*) shows the original arrangement and Fig. 3(*b*) the modern method; both are still in use. In the original method the opaque, separate, photosensitive mosaic elements 1 are formed on one surface of the insulating dielectric sheet 2, about 0·005 in thick, which is coated on the other surface with an opaque metal layer 3, termed the signal plate, and with which they form small condensers. The number of mosaic elements occupying the area of one picture point is usually high (10–100), and it is their capacitance in parallel that determines the capacitance available for charge storage. This is about 5×10^{-3} $\mu\mu$F per picture point, or 1000 $\mu\mu$F for the whole mosaic.

Initially it was found impracticable to make either a transparent conducting signal plate or a transparent photosensitive mosaic; hence, as shown in Fig. 3(*a*), the optical image had to be projected onto the exposed surfaces of the mosaic elements on which the scanning beam also impinged. This led to considerable inconvenience in the design of the tube. Later it became possible to make efficient transparent signal plates and photosensitive mosaics. The optical image could then be projected through the signal plate, dielectric and mosaic to liberate photo-electrons from the free surface of the mosaic. Thus the light and the scanning beam approached the target from opposite sides, as shown in Fig. 3(*b*), which was a great convenience in the design of the tube.

The Image Section

The photosensitive mosaic is relatively inefficient for the following reasons:

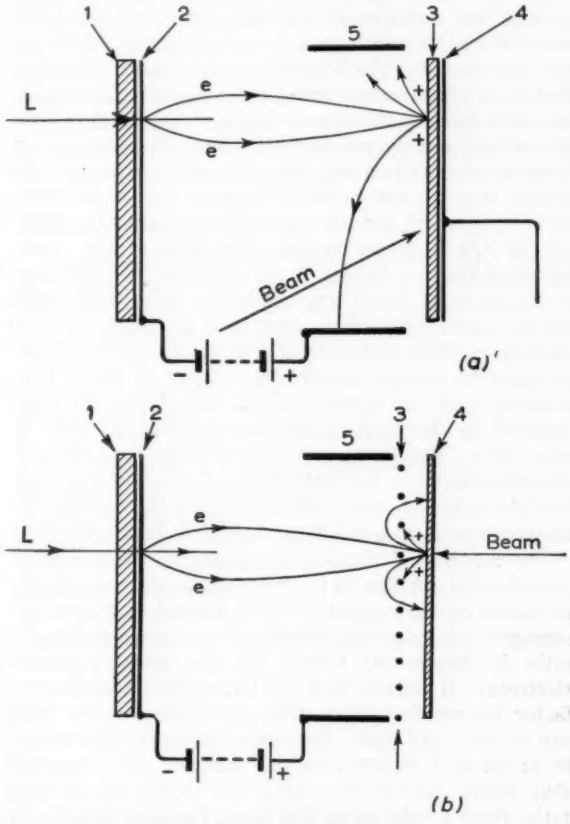
(i) The mosaic elements can never cover more than 60 or 70% of the whole area and hence some light is wasted between elements.

(ii) The activation of the mosaic cannot be pushed to its maximum since this tends to reduce insulation between mosaic elements; a slight excess of caesium is necessary to give maximum sensitivity and it is believed that this tends to bridge the insulating gaps.

(iii) Even in the modern method some light is lost in passing through the signal plate and dielectric.

These disadvantages are avoided and the advantage of one stage of electron multiplication of the electron stream is gained by the use of an image section, such as is shown in Figs. 4(*a*) and 4(*b*).

In Fig. 4(*a*) the light L of the optical image is incident on a transparent, continuous, conducting photocathode 2, which is supported on a transparent plate, e.g. of glass, 1, which may be the window of the vacuum tube. The photo-electrons *e*, released from the opposite side of the photocathode, are accelerated by a positive electric-force gradient between the photocathode 2 and the accelerator 5, and focused, usually by a magnetic field, onto the surface of the storage target, which consists of a thin sheet of insulating material such as mica, 3, backed by a metallic signal plate 4, which may in some tubes be connected to the signal amplifier. The surface of the target on which the photo-electrons impinge is treated in such a way that each primary electron liberates several, usually about five, secondary electrons. Some of these secondary electrons leave the surface of the insulator 3 and are collected on the neighbouring electrode 5; others return to the surface of the insulator, which is in effect a mosaic of extremely fine structure having a capacitance to the signal plate 4, on which the positive charges are accumulated. It will be apparent that one unit of light incident on the photosensitive surface in a device of the form of Fig. 4(*a*) will result in at least ten times the



4 *Diagrammatic sketch of image section*
(*a*) With single-sided target.
(*b*) With double-sided target.

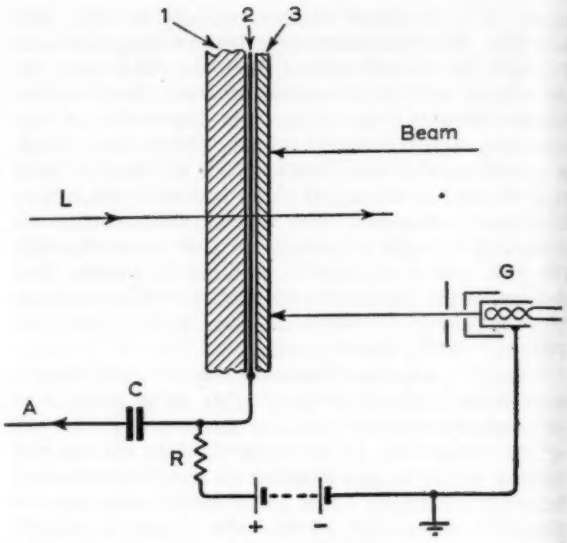
number of electrons being liberated from the charge storage mosaic surface as in a device such as shown in Fig. 3(*a*). This represents the factor by which the use of an image section can, in principle at least, increase the efficiency of a pick-up tube.

The charge storage target illustrated in Fig. 4(*a*) must be charged by the photo-electrons *e*, and discharged by the beam electrons from the same side. Hence the beam must be projected on to the mosaic at an angle which results in an inconvenient design. A different

type of target which avoids this difficulty is shown in Fig. 4(*b*). Here the target is double-sided, that is the photo-electrons build up charges on one side which are discharged by the scanning beam on the other side. The target consists of a very thin sheet of slightly conducting material 4, with a thickness of about 0·0001 in and a resistivity of 10^{12} ohm-cm; this is mounted close to a fine metal mesh 3 of at least 50% transparency maintained at a potential of about +2 volts relative to the glass film. As before, the photo-electrons *e* are focused on to the surface of the glass film 4 with an energy of about 500 eV. Those that pass through the metal mesh 3 release secondary electrons from the surface of the glass, a large proportion of which are collected by the slightly positive grid. Positive charges are thus accumulated on the surface of the glass, and these discharge the elementary condensers formed by this surface and the metal mesh. Since the dielectric of these condensers is a high vacuum and the area of the targets is small for practical reasons, the capacitance of this type of mosaic per picture point is about 5×10^{-4} $\mu\mu$F—much smaller than that of the types described above. In fact, it requires only 10^4 electrons to charge each elementary condenser fully under ideal circumstances, but when allowance is made for the shadowing effect of the mesh and the multiplication of the primary electron current by a factor of about 5, it is found that the number of primary photo-electrons required to charge each elementary condenser fully is about 10^3. The noise/signal ratio inherent in charges of this magnitude is $\sqrt{(10^3)}/10^3$ or about 3%, and since this is white noise, i.e. uniformly distributed throughout the frequency spectrum, it is large enough to be undesirable.

The number of primary photo-electrons is normally considerably smaller than the number of secondaries produced on the mosaic, which is limited by the charge storage capacity of the mosaic. Hence the signal/noise ratio is determined mainly by the primary photo-electrons. It follows that the larger the multiplication factor the smaller the number of photo-electrons that can be used and hence the worse the signal/noise ratio, in so far as it depends on this process. This suggests that, where possible, to achieve the highest signal/noise ratio, from a tube using this type of storage target, the multiplication factor in the image section should be kept near unity.

Owing to the comparatively small potential difference between the glass surface and the metal mesh, many secondary electrons escape capture by the metal mesh, and this becomes the rule once the condenser approaches full discharge, i.e. when the glass surface potential approaches that of the mesh. Many of these electrons then pass through the mesh and return to the target at varying distances from their points of origin. Since they return to the surface with low energy they tend to charge it negatively, i.e. in the sense opposite to that of the primary electrons. This effect is of importance in understanding the operation of a pick-up tube incorporating such a target and will be referred to again in Part II.



5 *Diagrammatic sketch of photoconductive target*

The positive charges built up on the surface of the thin glass film set free equal and opposite positive charges on its opposite side, and these can be discharged by the electrons of the scanning beam even if the glass film is a good insulator. However, in that case the tube would soon cease to function, leaving a potential difference across the glass film. In fact, the film is sufficiently conducting to allow this potential difference to be neutralized by a flow of current through it. The conductivity of the glass film is such that the time-constant of the small condenser formed by the two opposite surfaces of the glass element is small compared with the picture period. This is practicable, but the resistivity of glass being very dependent upon temperature the operating temperature of such a tube must be controlled fairly closely; if the tube gets too hot the conductivity of the glass will be too great and image definition will be lost because of lateral leakage across the glass film; if it is too cold considerable lag will appear in the pictures owing to the delay in transfer of charge from the "writing" to the "reading" side of the glass film.

The Photoconductive Target

The usual arrangement for using the photoconductive effect is shown in Fig. 5. The transparent supporting plate 1 has deposited on it a transparent conducting layer, or signal plate, 2 and on this is formed a thin layer of photoconductive material 3, e.g. selenium or antimony trisulphide. The free surface of the photo-conductive layer is stabilized at the potential of the cathode of the electron gun G (usually earth potential)

as described below; the signal plate is held at an adjustable potential of from +10 to +20 volts relative to earth through the resistor R and is connected to the amplifier through a stopping capacitor C. Thus a potential difference is established across the photoconductive layer which causes a positive current to flow from the signal plate to the free surface where possible. The positive charges so transferred are then discharged by the scanning beam to produce the picture signal.

This photoconductive layer must be an excellent insulator in the absence of light, but under the influence of the brighter parts of the optical image, and with about 10 volts applied across it, a current must flow of magnitude sufficient to give peak-white picture signal, i.e. about 10^{-7} amp in a modern amplifier of about 3 Mc/s bandwidth. Hence the resistance of the layer must be about 10^8 ohms, and since the thickness must be about 10^{-3} cm and the area 2 cm^2 the specific resistivity of the material of the layer under illumination must be about 2×10^{11} ohm-cm. The smallest significant signal is about 0·02 of peak white, corresponding to a signal current of about 2×10^{-9} amp and a resistivity of the material of 10^{13} ohm-cm.

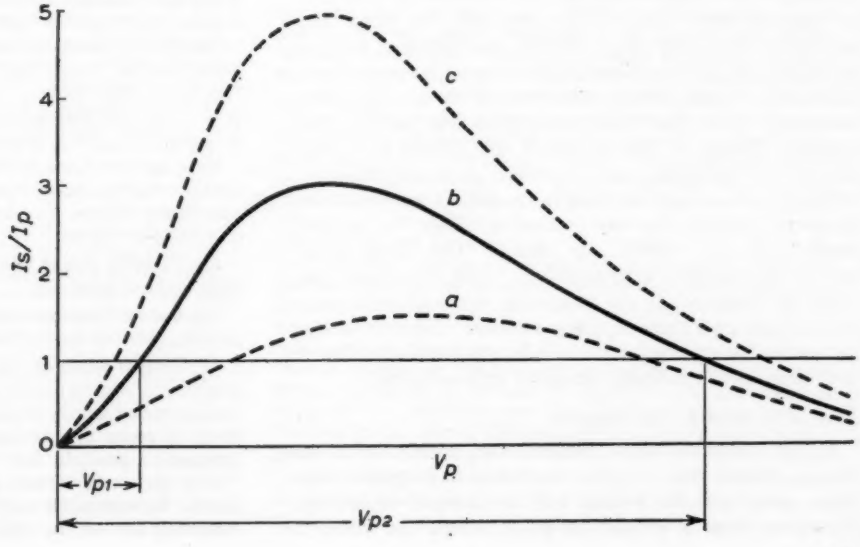
The resistivity of the photoconductor in the complete absence of light must be even greater than 10^{13} ohm-cm, for otherwise under the applied potential difference a current will flow through the layer comparable with that corresponding to the darker tones in the picture. This dark current will add noise to the signal but, more important, any variation in it due to variations in the nature or thickness of the layer will produce shading which will be noticeable in the picture. Since the charges must pass right through the layer it must be thin enough for a fair proportion of the incident light to do so. This limits the thickness to about 10μ, and since these materials have very high dielectric constants (10–15) the capacitance of unit area of such a layer is much higher than in any of the previous targets. This is a feature that has an important influence on the design of a tube employing such a target.

4 Mosaic Discharge and Signal Generation

Having integrated on the storage target the charges released by the photo-electric action of the light image throughout as much as possible of a complete frame period, the next process is to scan the storage target with some means capable of discharging the elementary condensers in sequence. This is usually a beam of electrons, and discussion will be restricted to the more important methods of using such a beam; but a beam of light might well be used and many suggestions have been made for applying the flying-spot method. Although it has been used successfully in film scanning, the flying-spot has not been incorporated in any existing pick-up tube and further reference to it will be omitted.

Secondary Electron Emission

To make clear the mechanism of discharging a mosaic by an electron beam it is necessary to outline the phenomenon of secondary electron emission from a surface bombarded by electrons. In Fig. 6 are plotted characteristic curves showing the relation between the number of secondary electrons liberated from a surface per incident primary electron (i.e. $i_s/i_p = \delta$) as a function of the energy V_p (in electron-volts) of the incident primary electrons. These curves are all of similar shape but vary from curve (*a*) for a poor secondary emitter through curve (*b*) for a medium, to curve (*c*) for a very good secondary emitter. Considering curve (*b*) we see that it crosses the ordinate $\delta = 1$ at two points corresponding to energies of the incident electrons of V_{p1} (*first cross-over potential*) and V_{p2} (*second cross-over potential*). That is, for electrons reaching the surface



6 *Secondary-emission characteristics*

with energies corresponding to accelerating voltages $< V_{p1}$ or $> V_{p2}$, the number of secondary electrons released by each primary, δ, on an average, is less than one. Between these energies δ is greater than one and passes through a maximum which may be as high as 10 or 15 for very good secondary emitters. These efficient emitters usually have low values of V_{p1} (10 or 15 volts) and high values of V_{p2} around 10 kV. Photosensitive surfaces are usually good secondary emitters though some good secondary emitters are not photosensitive.

Cathode Potential Stabilization

If an electron reaches a surface with energy less than V_{p1} it will add negative charge to that surface, and hence, if the surface is insulated electrically, it will drop in potential. This will reduce further the value of δ for electrons arriving subsequently, and the process will go on cumulatively until the surface reaches zero potential, or the potential of the surface (the cathode) from which the electrons originated (neglecting their initial energies and contact p.d.'s). Under these conditions the approaching electrons will cease to arrive on the surface and will be returned to some other collector.

If for any reason the surface acquires a positive charge, as illustrated in Figs. 3(*b*), 4(*b*) and 5, it will be discharged by the incident electrons and the potential returned to the original stable value which is termed cathode potential. This is a very important principle in the operation of pick-up tubes; it is used in three types to be described below, and is known as *cathode potential stabilization.*

Anode Potential Stabilization

If electrons reach the same insulated surface with energies between V_{p1} and V_{p2}, each will liberate, on an average, more than one secondary electron, and if all these secondary electrons are collected on a neighbouring electrode the insulated surface will increase in potential to approximately that of the electrode on which the secondary electrons are collected, stabilizing at such a potential that the bombarded surface loses one secondary electron for each primary that arrives on it. All other secondary electrons must return to the bombarded surface. Hence it follows that if the surface is a poor emitter its potential may stabilize strongly negative, while if it is a good secondary emitter it may even be positive, relative to the collector. This is termed *anode potential stabilization* and is that state most commonly found in cathode-ray tubes in which the electron beam scans an insulating surface, such as a fluorescent screen on a glass surface. Since it is the easiest stable state to achieve, it is not unnatural that it was used in the earliest television pick-up tubes.

Second Cross-over Stabilization

If the electron beam reaches the surface with an energy greater than V_{p2}, the coefficient will again be less than unity and the surface will be charged negatively. However, once it passes the point where the electron energy is less than V_{p2} the potential will rise again because $\delta > 1$. The surface potential will stabilize at a voltage V_{p2} relative to the cathode at which the beam electrons originate. Thus it is a stable state which could be used, and has been used experimentally, in television pick-up tubes. However, it is not used in any existing pick-up tube and is mentioned here for completeness.

5 General Requirements of Ideal Tube

From the varied components that have been described complete television pick-up tubes must be constructed to give the best possible performance. As the main features required in such tubes will be referred to frequently in Part II it will be useful to outline here the specification of the ideal pick-up tube. This may be set out as follows:

(*a*) **Sensitivity** must be as large as possible consistent with satisfactory performance in other respects. In some tubes it may be expedient to sacrifice some picture quality in favour of extreme sensitivity, e.g. for outside broadcasts; in other cases, such as studio operation, picture quality should be the primary consideration.

(*b*) **Definition** as near as possible to full modulation at the maximum number of picture lines envisaged must be achieved.

(*c*) **Geometry** should be such that residual distortion is not objectionable. This is difficult to specify but not difficult to realize.

(*d*) **Signal/Noise Ratio** must be such that the noise is not objectionable in the picture: the final criterion is subjective. About 30 dB for peaked noise and 35 dB for white noise represent the lower limits for the ratio.

(*e*) **Spurious Signals** such as shading, ghost images, haloes, etc., must be eliminated.

(*f*) **Black-level** must be determined independently of the picture content; once per frame, or preferably once per line, should be specified.

(*g*) **Contrast Law** given by the expression $S = B^{\gamma}$, where S is the signal strength and B the picture brightness, should have a value of γ variable from about 0·5 to 1·0. The γ of the normal reproducing cathode-ray tube is usually greater than 2; hence for the ideal condition such that the overall system has $\gamma = 1$ the pick-up tube must give signals of about $\gamma = 0{\cdot}75$. To deal with scenes of wide variation in contrast, it is desirable that it should be variable.

(*h*) **Exposure Time** is the effective time of integration of charges on the storage mosaic per picture frame. This must not exceed 1/25 sec (one frame period) and it would be useful if it could be varied.

(*j*) **Stability** should be such that the tube can accept excess light without paralysis.

(*k*) **Colour Response** should be as nearly panchromatic as possible without appreciable infra-red response.

(*l*) **General Features** such as size and shape must enable a convenient, efficient camera to be designed around the tube, incorporating an efficient and flexible optical system with lens turret or zoom lens, or both. The tube should be as easy to operate as possible and free from fatigue effects such as "burn on" and "sticking" and photographic effects. It should be reasonably easy to manufacture and have a good operating life—of the order of 1 000 hours.

ANNUAL GENERAL MEETING OF THE INSTITUTION

19TH MAY, 1955

MR. J. ECCLES, C.B.E., B.Sc., President, took the chair at the 83rd Annual General Meeting on the 19th May, 1955, at 5.30 p.m. He first announced that only Corporate Members and Associates were entitled to vote at the meeting.

The following list of donors to the Library for the year ended 31st December, 1954, was taken as read, and these donors formally received the thanks of the meeting:

A.C.E.C. Charleroi (Belgium); Admiralty; Air Registration Board; Edgar Allen & Co.; Allis-Chalmers Manufacturing Co. (Milwaukee); Aluminium Development Association; L'Aluminium Française; Aluminium Union; Amalgamated Wireless (Australasia); American Institute of Chemical Engineers; American Institute of Electrical Engineers; American Institute of Physics; American Radio Relay League; American Society of Civil Engineers; American Society of Mechanical Engineers; American Society for Testing Materials; American Standards Association; American Telephone and Telegraph Co.; *Annales de Radioélectricité*; E. H. Armstrong; A.S.E.A. Electric; Association of American Railroads; Association of Consulting Engineers (Incorporated); Association des Diplômés de Polytechnique (Montreal); Association des Ingénieurs Techniciens de Charleroi; Association of Short-Circuit Testing Authorities; Associazione Elettrotecnica Italiana; Ausschuss für Blitzableiterbau im Bundesministerium für Handel und Wiederaufbau; Automatic Electric Company (Chicago); Automatic Telephone and Electric Co.; E. H. W. Banner; B. J. Batsford Ltd.; C. S. Beckett; Belgelectro-Export; Bell Telegraph and Telephone Co.; Bell Telephone Laboratories Incorporated; Bern Brothers; F. A. Benson; B. K. Bhattacharyya; H. Blomberg; R. Bosch G.m.b.H.; British Aluminium Co.; British Broadcasting Corporation; British Brown-Boveri; British Coal Utilization Research Association; British Coke Research Association; British Council; British Electrical and Allied Industries Research Association; British Electrical and Allied Manufacturers' Association; British Electrical Development Association; British Engine, Boiler and Electrical Insurance Co.; British Institute of Radiology; British Internal Combustion Engine Manufacturers' Association; British Interplanetary Society; British Iron and Steel Federation; British Iron and Steel Research Association; British Productivity Council; British Standards Institution; British Thomson-Houston Co.; British Transport Commission; R. Brooks; Brush Group; Builder Publishing Co.; Butterworth's Scientific Publications; Cameroons Development Corporation; Canadian Standards Association; T. H. Carr; The Louis Cassier Co. Ltd.; A. E. Cawkell; Central Board of Irrigation (India); Central Electricity Authority; Chartered Institute of Patent Agents; I. H. Child; A. E. Clayton; Cleaver-Hume Press; College of Technology, Manchester; Colonial Development Corporation; Commission mixte internationale pour les expériences relatives à la protection des lignes de télécommunication et des canalisations souterraines; Commonwealth Scientific and Industrial Research Organization; *Compressed Air Engineering*; Conférence internationale des grandes réseaux électriques; Constable and Co.; Copper Development Association; Corporation of the City of Cape Town; H. Cotton; Council for the Preservation of Rural England; Crosby Lockwood and Son; G. Cumberlege; Danish Academy of Technical Sciences; Dansk Ingeniørforening; Department of Government Electrical Undertakings, Ceylon; Department of Scientific and Industrial Research; Derby Society of Engineers; Doshisha University (Japan); A. T. Dover; Economic Commission for Europe; Éditions Eyrolles (Paris); P. Eisler; Electric Lamp Manufacturers' Association; Electric Railway Society; Electrical Association for Women; Electrical Communication Laboratory, Tokyo; Electrical Contractors Association; *The Electrical Manufacturer*; Electrical Power Engineers' Association; Electrical Review Publications; Électricité de France; Electricity Corporation of Nigeria; Electricity Supply Commission (Johannesburg); Electricity Supply Commission of Southern Rhodesia; *Electro-Magazine* (Paris); Électromécanique S.A. (Brussels); Elin A.G. für Elektrische Industrie; Elliot Bros. (London); Engineering Ltd.; Engineering Institute of Canada; English Electric Co.; Federation of British Industries; Federation of Malaya; Federation of Master Builders; Fédération professionelle des producteurs et distributeurs d'électricité de belgique; H. G. Ferguson; J. L. Ferns; Fire Protection Association; Garraway Ltd.; Gasaccumulator Co.; Messrs. Gauthier-Villars; General Electric Co.; General Electric Co. (Schenectady); Glasgow University Engineering Society; Glenfield and Kennedy; P. Goudal; Government of Northern Ireland; A. E. Greenlees; F. C. V. Grils; Verlag Guggenbuhl and Huber (Zürich); Hasler A.G. (Bern); C. Hayashi; W. T. Henley's Telegraph Works Co.; Alfred Herbert Ltd.; High Commissioner for Canada; High Commission of India; H.M. Postmaster General; H.M. Stationery Office; Honeywell-Brown Ltd.; Huber & Co., A.G. (Frauenfeld); E. Hughes; Hydro-Electric Power Commission of Ontario; Iliffe and Sons; Illinois Institute of Technology; Illuminating Engineering Society (London); Imperial Chemical Industries; Indian Posts and Telegraphs Department, Jabalpur; Ingeniors Vetenskaps Akademien, Stockholm; Institute of Actuaries; Institute of Arbitrators; Institute of Fuel; Institute of Marine Engineers; Institute of Metal Finishing; Institute of Physics; Institute of Radio Engineers; Institution of British Agricultural Engineers; Institution of Certificated Engineers, South Africa; Institution of Civil Engineers; Institution of Engineers, Australia; Institution of Engineers, India; Institution of Heating and Ventilating Engineers; Institution of Locomotive Engineers; Institution of Mechanical Engineers; Institution of Post Office Electrical Engineers; Institution of Production Engineers; Institution of Railway Signal Engineers; Institution of the Rubber Industry; Institution of Structural Engineers; Institution of Works Managers; International Committee for Bird Protection; International Council of Scientific Unions; International Electrotechnical Commission; International Scientific Radio Union; International Telephone and Telegraph Corporation (New York); Israel Institute of Technology; Professor Willis Jackson; George Kent Ltd.; Walter King Ltd.; Kyushu University (Japan); Lancashire Dynamo and Crypto Group; John Lane (Bodley Head); Laurence, Scott and Electromotors; Leeds Association of Engineers; Leeds and Northrup Co. (Philadelphia); I. A. D. Lewis; Light Railway Transport League; Lighting Service Bureau; The Liverpool Engineering Society (Incorporated); Lloyd's Register of Shipping; London Electricity Board; Longmans, Green & Co.; Macdonald and Co. (Publishers); McGraw-Hill Publishing Co.; Professor J. T. MacGregor-Morris; Machinery Lloyd; *Machinery Market*; Machinery Publishing Co.; The Macmillan Co. (New York); Manchester Association of Engineers; Marconi's Wireless Telegraph Co.; Meddelanden från Kungliger Telegrafstyrelsen; Professor J. M. Meek; Methuen and Co.; Metropolitan-Vickers Electrical Co.; Metropolitan Water, Sewerage and Drainage Board, Sydney; Midland Silicones; Ministry of Civil Aviation; Ministry of Fuel and Power; Ministry of Health; Ministry of Supply; *Modern Refrigeration*; Mond Nickel Co.; Muirhead and

Co.; Mullard; Murex Welding Processes; Murphy Radio; N.A.G. Press; National Central Library; National Electrical Manufacturers' Association; National Register of Electrical Installation Contractors; National Research Council (Washington); National Smoke Abatement Society; New Zealand State Hydroelectric Department; Norsk Elektroteknisk Forening; North of Scotland Hydro-Electric Board; N.V. tot Keuring van Electrotechnische Materialen; Oerlikon Ltd.; Ohio State University; Organization for European Economic Co-operation; A. M. F. Palmer; The Parkside Press (Dublin); G. Parr; C. A. Parsons and Co.; N.V. Philips Gloeilampenfabrieken; S. F. Philpott; Physical Society; Sir Isaac Pitman and Sons; Polytechnic Institute of Brooklyn; Polytechnic Weekly Magazine (Amsterdam); P. G. Provoost; The Public Transport Association; Radio Corporation of America; Rand Water Board; R. C. A. Photophone; R. C. E. Reid; J. H. Reyner; A. Reyrolle and Co.; Rhodesian Institution of Engineers; John F. Rider, Inc.; W. K. Roots; Royal Astronomical Society; Royal Electrical and Mechanical Engineers; Royal Institute of British Architects; Royal Institute of Chemistry of Great Britain and Ireland; Royal Institution of Chartered Surveyors; Royal Institution of Great Britain; Royal Meteorological Society; Royal Society; Royal Society of Edinburgh; Rugby Engineering Society; S.A. des Ateliers de Sécheron; R. G. Sacasa; Schweizerischer Ingenieur- und Architekten-Verein; *Science Abstracts*; The Science Club, Calcutta; Science Council of Japan; *Scottish Electrical Engineer*; *Short Wave Magazine*; H. N. Shrivastava; Siemens Brothers and Co.; Siemens und Halske G.m.b.H. (Vienna); Singapore Improvement Trust; A. J. Small; Société financière de transports et d'enterprises industrielles; Société générale de constructions électriques et mécaniques; Société des Ingénieurs Civils de France; Société mixte pour le développement de la technique des télécommunication sur câbles; Société Royale Belge des Ingénieurs et des Industriels; Society of Power Engineers (Simla); South African Council for Scientific and Industrial Research; South African Institution of Civil Engineers; South African Institution of Mechanical Engineers; E. and F. N. Spon; Springer-Verlag; Standard Telephones and Cables; A. T. Starr; State Electricity Commission of Queensland; S. A. Stigant; Sulzer Brothers (London); The Superheater Co.; Svenska Elverksföreningens; Swedish Chamber of Commerce for the United Kingdom; Taylor and Francis; The Technical Association of Malaya; Technical Publications (Wellington); Technion Society of Great Britain; Teknisk Ukeblad; Tekniska Föreningen i Finland; Telefonaktiebolaget L. M. Ericsson; Telefunken G.m.b.H.; Telephone Engineer Publishing Corporation; Telephone Manufacturing Co.; Telephony Publishing Corporation; Television Society; Temple Press; Th. Thelander; Timber Development Association; Trinidad and Tobago Electricity Commission; Union internationale des producteurs et distributeurs d'energie électrique; United Nations Economic and Social Council; United Nations Educational, Scientific and Cultural Organization; Universidad Nacional de Eva Peron; University of Cambridge; University of Washington; Verein Deutscher Ingenieure; Vulcan Boiler and General Insurance Co.; Thomas Wall and Sons; J. W. T. Walsh; W. P. Warren; F. H. Wells; Welmec Corporation; J. C. West; Western Union Telegraph Co.; Westinghouse Electric International Co.; G. E. Williams; A. H. Willis; World Power Conference.

The President next formally presented the Report of the Council for 1954–55 and moved its adoption, which was seconded by Mr. L. W. Phillips. In introducing the Report the President said:

"The Council are very glad to be able to report that the rate of growth of membership has been maintained, but they are concerned about the rate of recruitment of junior members to The Institution. It goes further than that. We are, or should be, worried, as professional electrical engineers, about the rate of recruitment to the electrical industry, because broadly the accretion of membership to The Institution in the junior grades is almost a direct reflection of the number of people joining our industry in the professional ranks. This problem has been given much attention, and in the Report you will see some of the steps which have been taken. These include the preparation of a special careers booklet and the production of a film called 'The Inquiring Mind.' Here I would express, on behalf of the Council, our thanks to all those donors who have contributed so generously and made the production of this film possible. The film is nearly completed and will probably be available for its *première* within a month. It is intended that this film should be shown to the senior boys of public and grammar schools. It calls attention to the interest and value of electrical engineering as a career, without specializing in any particular branch of electrical engineering, and we hope that, as is fitting for The Institution, it will be a comprehensive documentary.

"The Council are a little exercised about the people nowadays who decide to enter The Institution at a comparatively advanced age. What with other attractions and the superposition of military service, we are not getting the same number of Student members that we were some years ago. Quite a number of people prefer to postpone their entrance to The Institution until they are qualified as Graduates. The Council have this very actively in mind and in due course you will hear what they are doing, but that belongs to the present year's activities rather than to the year 1954–55. The Council and its special Committee are giving active consideration, however, to the recruitment of young men as junior members of The Institution.

"During the year representatives of the Council have had discussions with the Ministry of Education and the National Advisory Council on Education for Industry and Commerce. The results have not been all that we could have wished, because successive Ministers of Education and their Advisory Committee have felt disinclined to accept the advice which was proffered by the three major engineering Institutions and want to adopt a rather more general and lax policy than we would wish in the matter of technical education. Originally their thought was that all the technologies should be grouped together and that hairdressing and brewing had almost the same status as engineering. It has been our duty and privilege to point out that the repercussions and implications of sound engineering technology have a much wider range and a much deeper effect on the national economy of this country, and indeed throughout the Commonwealth, than whether someone's hair is curled vertically or horizontally or whether beer is above or below strength. We have gone a long way from there, but the Council and the Minister of Education are not yet seeing eye to eye. As you know, the House of Commons is dissolved at the moment and its members are otherwise engaged in educating the public in a rather different sense. The Council can only await the return of a new Parliament and then begin discussions again where they were left off with the present Minister. The Council have emphasized that

they are ready to meet him at any time, so that the door is still open.

"The education of engineers in the colonies has received much attention. The Secretary of State for the Colonies has confirmed that he will encourage the provision of faculties of engineering science in colonial universities. Within the last two months the Secretary has flown to West Africa and discussed with people on the spot the development of technological education in that territory. That is just one instance of the kind of interest that The Institution takes in the development of the Commonwealth, and particularly in the development of its more technically and industrially backward parts.

"Works-based sandwich diploma courses, under which a man is in a works and attends college, for six months or a year, have been developed and are operating smoothly. This is a feature of technical training which the Council believe will have far-reaching effects upon not only the academic attainments of these young men but also their immediate practical experience.

"Members may not know that five of the professional Institutions have grouped together with a view to promoting what has been called, for lack of a better title, the British Nuclear Energy Conference. That is a collective body formed by The Institutions of Civil and Mechanical Engineers, ourselves, The Institute of Physics and The Institution of Chemical Engineers. It is controlled by a Board composed of members of those Institutions, and capable of being extended and expanded to embrace other learned societies as circumstances warrant, with the intention of presenting a British front on nuclear energy matters. It will publish a journal which will cover all the engineering, and perhaps the physical applications, of nuclear energy for peaceful purposes. It will arrange for the presentation and discussion of papers, and the representation of the United Kingdom at conferences abroad and other international gatherings of that kind. It is felt that we should have such an organization to represent this country in her relations with American and European countries who are doing the same kind of thing.

"Last summer there was a meeting of the Commonwealth Engineering Conference, in which all the professional engineering societies of the Commonwealth similar to ourselves met to discuss their common problems. They were the guests of the three Engineering Institutions of this country. Representatives were present from Canada, Australia, New Zealand, South Africa, India and the Federation of the Rhodesias. They sat round the table to discuss common problems of organization, of professional ethics and all those things which can make for the usefulness of professional institutions. It was very refreshing for us at home to hear what the Commonwealth countries, with their fresh and new outlook on many problems, had to say about these matters. This is something which started just after the war. The first Conference was held in London in 1946 and the second, four years later, in Johannesburg in 1950. After another interval of four years the Conference met again in London, and the fourth Conference will be held in Australia in 1958. This is one of the minor threads which form part of the great cord holding the Commonwealth together, and for anyone who has the privilege of attending these meetings it is a very stimulating experience.

"We are associated with the European group of Engineering Societies commonly called EUSEC, and there is a third group which—following this abomination of using initial letters—is called UPADI, the corresponding organization for North and South America. There are thus three engineering organizations of this kind in the world at the moment: the Commonwealth Engineering Conference; EUSEC, covering all free Europe; and UPADI, for the Americas. Representatives of these three organizations periodically meet together and can do much to reach common understanding and a common standard, which in the end can help only to promote world peace.

"Members will be aware of the new form which the *Journal* has taken this year. In January the first of the new series was issued, and it has been the subject of very favourable comment. It has a lighter form than its predecessor, and it includes a correspondence column and items of topical interest at home and oversea. We have reason to know that it is very welcome to our young people who have recently gone oversea and are anxious to know what is happening at home. If the colour of its cover is any criterion it ought to have a good circulation.

"The Wiring Regulations are being revised. The 13th edition is nearing completion and will, we hope, be published this summer.

"I do not think that I need say more at this stage, except to record the thanks of the Council to the many honorary officers and other members at home and oversea who give so freely of their time and interest to The Institution. There will be a formal resolution of thanks to them later in the meeting.

"The very last paragraph of the Report is an acknowledgment of the work done by the Institution staff. Although that is expressed in only five lines of print, I like to think that this is so simply because we cannot express fully enough our appreciation of the work of Mr. Brasher and his staff in the management of The Institution, of the forward-looking policy which they always aid the Council to adopt and of the high ethical standard which they maintain in carrying out their duties. I should like to say very sincerely to Mr. Brasher, and through him to his staff, how much we appreciate the work which they do for us."

The President next announced that the Report was now before the meeting for discussion. He went through the Report page by page inviting comment on particular items. In the event, there was only one speaker from the body of the meeting, Mr. L. W. Phillips, who, in the course of his remarks, said:

"I am diffident about speaking to-night, but I feel that in the interests of The Institution someone from the

rank and file should speak; this is our meeting, and there is a danger, with our increasing membership, that we shall have simply a record of people who want to become members because of the professional value of membership, but who are not part of the corporate body, as we all should be. You can see that in the fact that we have nearly 40000 members, but only about 40% of them, or 16000, belong to any one of the Specialized Sections. In the Sections lies our hope. If we are going to count for something in the land we must be a corporate body and have fellowship amongst ourselves. I should like, therefore, to see a growth in the membership of the Specialized Sections."

Mr. Phillips next declared that The Institution did not occupy the time of its Chaplain enough. He would like to see a service held in the Queen's Chapel of the Savoy at the beginning of each session. Electrical engineers should feel that there was something in their profession that enabled them to witness to the glory of God, and render service to the community. Joy was in doing one's job and not in the money that came from it.

"With regard to education," he said, "we are trying to push everyone along a narrow academic channel, and that is not right. You will find that more and more men at the end of their university career know how to remember and not how to think. They are walking encyclopaedias and know a great deal about one particular technical subject but very little about life. They do not use their brains but refer back to what they have learnt. They pass their examinations not on ability but on memory. If we are to have a profession which is worth while, we must have a broader avenue of training than that which comes purely through a university."

He continued by stating that The Institution was on dangerous ground over technical books; he could not agree that there was a shortage of them. In order to get the best authors, firms must give their staffs time to write books. Mr. Phillips ended his speech with a tribute to the Institution Secretariat.

The President thanked Mr. Phillips for his suggestions, which would be looked into individually. But he did not think it was likely that any revolutionary changes would be called for, because he was sure that Mr. Phillips and the Council were not really far apart in their views. Most members of The Institution had a lively appreciation of the need for something other than pure technology in people's lives.

Mr. S. E. Goodall rose to reply briefly, on behalf of the Education and Training Committee, to one or two of the points which Mr. Phillips had made. He had said that it appeared to be the Council's policy that the education of engineers should be conducted in a narrow channel, through the universities only. Mr. Goodall stated firmly that this was untrue. Mr. Phillips had said also that it appeared to be their policy to cram as much material as they could into a man's brain while he was at a university and not to teach him to think. "Anyone," said Mr. Goodall, "who studies carefully the recent modifications that The Institution has made in its own examinations can draw his conclusions about that." What the Council was really aiming at was quite the contrary to what Mr. Phillips had asserted.

The motion for the adoption of the Report was then carried unanimously by the meeting.

The President said next that he had pleasure in inviting the Honorary Treasurer, Mr. H. W. Grimmitt, to present the Accounts for the year ended 31st December, 1954. Mr. Grimmitt introduced the Accounts as follows:

"The report on the Accounts for the year 1954 is the last which it will be my pleasure as Honorary Treasurer to present to you. I am happy to say that the past year has been financially sound. At a first glance, looking at the excess of Income over Expenditure at the foot of the Accounts, you will see an item of £1 455, but this is not the total net surplus. The total net surplus includes the £7 481 which is the interest on our investments and the £10000 transferred to the General Reserve Fund, so that the real net surplus for the year is £18936. The actual surplus has exceeded the original estimated surplus by a fair margin, owing to the income being larger than was expected, while the expenditure for the year was only a little above that estimated. This is due to the fact that while we can and do control expenditure we must await the income and budget hopefully.

"On the Income side of the Accounts, each of the first three items is a little higher than was anticipated. The interest on investments shows an improvement of over £1000 on the previous year. This is partly due to a transfer from some long-dated securities into shorter-term stock and partly to purchase of additional stock. The sale of sundry publications exceeded very considerably all expectations. The high figure is largely the result of the continued sales of The Institution's best seller, the Wiring Regulations. Examinations and National Certificates show an apparent excess of nearly £400 over the previous year. The approximate costs of their administration, etc., are shown for the first time in the Accounts; these figures are approximations only, and a large portion of them covers staff salaries. The sale of the proceedings of conventions has been better than was estimated, but this must naturally be reduced as the stocks of these become exhausted until further conventions are held.

"The remaining item on the Income side is members' subscriptions to *Science Abstracts*. The figure is lower than in 1953, but the true position here is seen by reference to the expenditure under this head, which was also lower than in 1953. The net result is that this publication has cost The Institution £103 more in 1954 than in 1953. This is the one item where the income has failed to reach the target figure. It would be useful if The Institution received more subscriptions to *Science Abstracts*.

"It is not necessary for me to deal at length with the Expenditure items, except perhaps to mention the *Journal* and *Proceedings*. Here a saving of £2023 on the previous

year is shown. This is due mainly to improved receipts from advertisements. I think, however, you may be interested to have an approximate breakdown of The Institution's expenditure under a few broad headings:

	Approximate percentage of expenditure
General Administration, Finance Department, Membership (Elections, Transfers, Records, etc.), and Building Upkeep	21
Journal and *Proceedings*, including the *Students' Quarterly Journal*	35
Local expenditure in Centres and Oversea Branches	9
Meetings expenses, etc., at Headquarters (including Specialized Sections)	8½
Education Department, Examinations, National Certificates and Scholarships	8
Technical Department: preparation of Regulations, Codes, etc.	6
Reference and Lending Library	5
Other items, i.e. grants to Other Bodies, Annual Dinner, Conferences, etc.	7½

"Turning to the Balance Sheet, there are only a few entries which require comment, the first being the Rebuilding Reserve Fund, which appears under Liabilities. This reserve was created in 1953, and has been increased during the year by the amount of the dividend income, namely £7 481, and by the gain made on the sale of securities. The securities sold were long-dated, and they have been replaced by shorter-dated ones, the effect of which is to strengthen the capital position in readiness for rebuilding, which may be possible within a few years. Although there has been a gain by the sale of some securities, it was in fact a conversion operation. The investments are shown on the other side of the Balance Sheet.

"The General Reserve Fund now stands at £20 000, and £4 930 of this had not been invested at the end of the year. Securities for this amount have since been purchased.

"The market value of the securities held by the Rebuilding and General Reserve Funds was on the 31st December, 1954, £221 above the cost price, a paper gain, against a paper loss in December, 1953, of £4 193. This does not hold good to-day, for there is now a paper loss of over £10 000. The investment market has fallen since the end of last year, with the increase in the Bank Rate on February 24th. As we do not require to sell any securities, this is not important at present.

"The remaining pages contain various Trust Fund accounts, which do not require comment, with the exception of the Paul Scholarship Fund on page 443. This fund has benefited by a legacy of £3 000 from the estate of the late Mrs. A. Paul, and the income available for awards will be increased by over £105 annually."

The President formally moved the adoption of the accounts, and Sir John Hacking seconded the motion.

Mr. L. L. Goodman suggested that The Institution should follow the practice of the Church Commissioners in its investments and not have all its eggs in British and Commonwealth Government and municipal securities and public boards. Even the Life Offices were now investing about 20% of their funds in industrial equities. There was no doubt felt in some circles that we should have a 3% decrease in monetary values in the next three or four years. He suggested that The Institution should have 20% of its invested funds in industrial equities.

The President replied that Mr. Goodman had anticipated the action of the Council by about a month, because at a Special General Meeting members would soon be invited to change some of the conditions of the Royal Charter. It was their intention to follow the changes in the Charter with changes in the Bye-laws, including the Bye-law giving particulars of how The Institution might invest its funds.

The motion for the adoption of the Accounts was then carried unanimously, and the Auditors, Messrs. Allen Attfield and Co., were reappointed for the year 1955.

Professor E. Bradshaw proposed: "That the best thanks of The Institution be accorded to the Honorary Secretaries of the Local Centres and Sub-Centres, the Council's Representatives Oversea, and the Honorary Secretaries of the Oversea Branches and Committees, for their valuable services during the past year." The resolution was seconded by Mr. G. Caton and carried unanimously.

Mr. T. E. Goldup proposed: "That the best thanks of The Institution be accorded to the Honorary Treasurer, Mr. H. W. Grimmitt, for his valuable services during the past year." In doing so he said:

"At the Annual General Meeting it is customary to refer to the work of the Honorary Treasurer. It is my pleasure and also my privilege this evening on behalf of you all to move a vote of thanks to Mr. Grimmitt. Those of us who have sat in committee with Mr. Grimmitt realize that behind his quiet manner there is a great deal of thought in everything that he says. In the Finance Committee he says very little, but what he does say is very well worth while and is usually taken great note of. In addition to his work as Honorary Treasurer I think that I ought to remind you of some of his other activities in The Institution. He serves on the Membership Committee; he is the Council's Representative on the Court of Governors of the Benevolent Fund; he has twice served on the Council; he is a Past-Chairman of the Supply Section, and so one could go on.

"This evening he has introduced his third financial report—and his last, because he has now, in accordance with the Bye-laws, to give up his office to someone else. I am sure that I voice the feelings of you all when I say that not only his work as Honorary Treasurer but all his work for The Institution is much appreciated by us and we are very grateful to him for all that he has done."

The resolution was seconded by Mr. J. Bennett and carried unanimously.

The Annual General Meeting then ended and was followed, after an interval of a few minutes, by a lecture on "Human Relations in Industry," by the Rt. Hon. Lord Citrine; the text of this will be published in a future issue of the *Journal*.

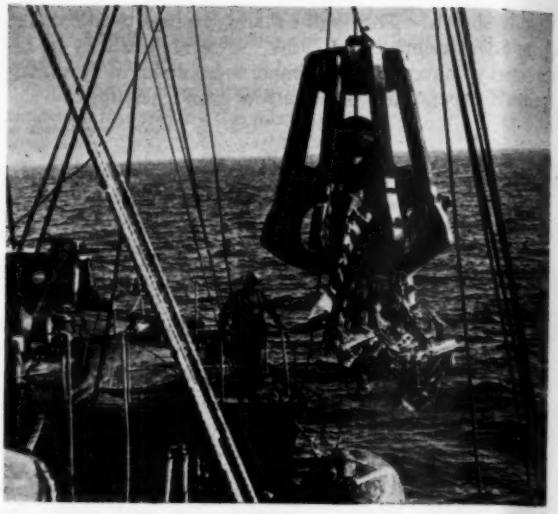
THE COMET CRASH

On the 21st February, 1955, Commander C. G. Forsberg, O.B.E., R.N., and Mr. G. G. MacNeice, B.Sc., delivered an informal lecture on "The Recent Search for, and Salvage of, the Comet Aircraft near Elba" at a meeting of the Radio Section. A summary of their remarks, and of the subsequent discussion, appears below.

COMMANDER C. G. FORSBERG and Mr. G. G. MacNeice began the lecture by reminding those present that, after the tragic loss of the Comet aircraft in the Mediterranean Sea on the 10th January, 1954, the Ministry of Transport and Civil Aviation—who attached supreme importance to the recovery and examination of the wreckage—sought the services of the Admiralty. The subsequent operation, involving unprecedented difficulties in location, identification and salvage, was ultimately successful. Some 71% of the wreckage was recovered, representing a weight of 45 tons; this included a d.f. aerial panel, only 9ft² in area; its recovery subsequently enabled the investigators to confirm their conclusion as to the cause of the accident.

The first part of their lecture dealt with the naval side of the operation, which involved the constant use of five ships of the Royal Navy for 2½ months, and in addition, a small fleet of chartered Italian fishing trawlers. The search area, reduced to some 25 square miles by the scant but useful information obtained from a few eye-withesses and other sources, was scanned by a frigate's acoustic devices and combed by the fleet of trawlers. During the earlier phase, carried out under severe weather conditions, many contacts, detected and painstakingly examined, proved to be no more than old enemy mines and similar material. Later, batches of aircraft wreckage

1 *One of the four jet engines recovered by the grab*



2 *A 4½-ton salvage grab bringing in one of its many loads*

3 *Composite picture from three photographs taken of the television screen as the camera passed over some Comet wreckage on the sea bed*

(Fig. 1) were identified and successfully raised, piece by piece, to the surface from a depth of over 400 ft by means of an 8-jawed salvage grab (Fig. 2) directed under water by a diver in an observation chamber. Six heavy anchors and miles of mooring wires had to be shifted and carefully laid around each site in order to hold and control the salvage vessel with sufficient accuracy.

The second part of the lecture dealt with the underwater-television aspect. At the time the search began there existed only two underwater cameras suitable for the required depth. Both had been developed by the Admiralty after their successful use of television to identify and examine the wreck of H.M. Submarine *Affray*, and they had proved very useful in areas where the water clarity was good. The main advantages are that a television camera can be used under conditions which may endanger a diver, and that it enables experts to examine objects visually (Fig. 3) instead of having to rely solely on verbal descriptions. The disadvantages of the method are its inability to discriminate, its high cost, and the need for a skilled operator. In all, three television equipments were used: the Admiralty's own set, supplemented later by sets quickly prepared and lent by each of two firms in the radio industry. The camera lent by one of these firms was fitted with a periscopic lens attachment which had recently been developed.

In the general discussion the lecturers were able to amplify their account by their replies to some of the questions raised. It was first asked why it had not been possible to bar all other shipping from the search area and thus prevent collisions with mooring wires and similar mishaps. The lecturers explained that vessels could only be advised and not compelled to avoid the scene of operations. The main wreckage was found to be spread over an area of approximately 2 square miles and the lecturers estimated that about one-third of that recovered was retrieved by simple trawling, the remainder with the aid of television cameras and commercial salvage technique. It was suggested that the poor picture quality due to turbidity of the water on the sea bed—on calmer sea days the permitted range was 10–12 ft, on agitated sea days only 4–5 ft—might have been improved to some extent by auxiliary lighting separated from the camera. The lecturers said that this was tried, but difficulties of controlling and the hindrance of additional cables did not render it worth while. The heavy iron content of the Elba land-mass and adjacent sea-beds not only interfered with compass readings in the initial determination of bearings, carried out subsequently with sextants, but precluded the use of magnetic detectors over any part of the area examined.

After identification of a piece of wreckage by means of the television camera, a camera was also used for its closer inspection, and here the periscopic lens attachment proved its value by providing sufficient picture adjustment to compensate for ship movements. The whole procedure was made difficult by the impossibility of arresting the salvage ship sharply or arranging it to "hover" after a piece of wreckage had been sighted on the television screen. The television camera was not used to direct the grab, this being carried out by an expert team of divers using the observation-chamber technique when necessary.

The lecture was illustrated by a number of lantern slides and a brief unscripted film of aspects of the operations.

THE INQUIRING MIND

A scene in an industrial design office from The Institution's new film production "The Inquiring Mind" (see Annual Report, page 430). The film, which has been sponsored by The Institution in collaboration with trade associations, industrial firms, and other organizations employing chartered electrical engineers, was given its première before an invited audience at Savoy Place on the 23rd June, 1955. The film includes a vivid, exciting portrayal of the whole compass of electrical engineering and will, although primarily addressed to schoolboys, undoubtedly appeal to all members. Members will have opportunities of seeing it later in the year, and it is of course available for loan to schools.

ANNUAL REPORT FOR 1954-55

Report of the Council presented at the Annual General Meeting on the 19th May, 1955

INTRODUCTION
SECTION A Membership
SECTION B Institution Activities
SECTION C Technical Investigations
SECTION D Joint Activities with Other Bodies
SECTION E Education
SECTION F Institution Library and Publications
SECTION G Benevolent Activities
SECTION H Institution Staff
APPENDIX A Membership Changes during the Year
APPENDIX B Growth of Membership over the last 15 years
APPENDIX C Meetings
APPENDIX D Organization and Government of The Institution
APPENDIX E Index

Introduction

The Council have pleasure in presenting at this the Eighty-Third Annual General Meeting of The Institution their Report for the year ended 31st March, 1955.

The rate of growth of Institution membership has been maintained at the level noted in previous Reports, but is still insufficient in view of the national need for adequate numbers of professionally qualified electrical engineers. The Council have given much attention to this problem of recruitment to the profession, and elsewhere in the Report details are given of some of the steps which have been taken such as the preparation of a careers booklet and the production of a film designed primarily to interest elder schoolboys. Of the young men who decide to make electrical engineering their career, the proportion who join The Institution at an early age, prior to becoming Corporate Members, is too low. This is a separate problem, and it arises from a variety of reasons which are being actively studied.

During the year discussions continued with the Minister of Education and the National Advisory Council on Education for Industry and Commerce. In the result much misgiving is felt at the Minister's reluctance to accept the advice offered by the three Engineering Institutions on the future development of technological education, and the Presidents of the three Institutions have recently written to the Minister emphasizing the views of the Institutions.

In view of the current shortage of textbooks in electrical engineering, a Technical Publications Panel has been formed with the object of encouraging the publication of textbooks, particularly those of post-graduate standard. Authority has been given for the establishment of an "Institution Series" of textbooks.

The education of engineers in the Colonial territories has also received much attention, and after discussions with representatives of the three Institutions, the Secretary of State for the Colonies has confirmed that he will encourage the provision of Faculties of Engineering Science in Colonial Universities.

The introduction of works-based sandwich diploma courses has been welcomed by industry. A new Scholarship for students pursuing these courses has been introduced and will be known as "The Arthur Fleming Scholarship" to commemorate Sir Arthur Fleming's life-long interest in the education and training of persons employed in the electrical engineering industry.

A second Conference on Courses for Electrical Technicians was held, and proposals were put forward by the Conference for a basic course for electrical technicians. Detailed syllabuses for the first three years and for the second and specialized part of a five-year course are receiving the attention of the City and Guilds of London Institute.

In the Institution Examination, the former Section A has been replaced by the new Part I. Under the revised arrangements for the conduct of Part I and the participation of The Institution of Mechanical Engineers therein, the three Engineering Institutions are now equal partners in the scheme; provision has been made in the terms of reference of the controlling Committee for the admission of other engineering Societies.

Discussions are in progress with a number of other learned Societies for the establishment of a "British Nuclear Energy Conference" which will co-ordinate the work of the supporting Societies in the field of nuclear energy and provide a channel for the dissemination of technological information regarding development of nuclear energy in Great Britain.

In response to a request, the views of the Council on a number of matters falling within the purview of The Institution have been conveyed to the Committee of Inquiry into the organization and efficiency of the electricity supply industry in England and Wales.

The Conference of Commonwealth Engineering Institutions took place in London in May, 1954, and was attended by representatives of Engineering Institutions from six Commonwealth countries and by representatives of the three home Institutions. This Conference was followed by a meeting of delegates from the Commonwealth, Eusec, and Upadi Conferences which was held in Brussels. Problems of common concern to Engineering Societies in this country and the Commonwealth, in Western Europe and in the Americas, were discussed.

The publication arrangements for the *Journal* and the *Proceedings* of The Institution were reviewed and a number of alterations decided upon; for example, the *Journal* has been completely re-designed and has been the subject of much favourable comment.

The Thirteenth Edition of the Regulations for the Electrical Equipment of Buildings is nearing completion and will, it is hoped, be published during the summer, 1955.

In conclusion the Council would again like to record their grateful thanks to the many Honorary Officers and other members, both at home and oversea, who give so freely and willingly of their time in the interests of The Institution.

SECTION A Membership

1 The Register

The rate of increase in the membership of The Institution has been maintained, the number of members elected during the year being 2200 compared with 2400 in 1953/54. The Membership Committee dealt with 2174 other applications,

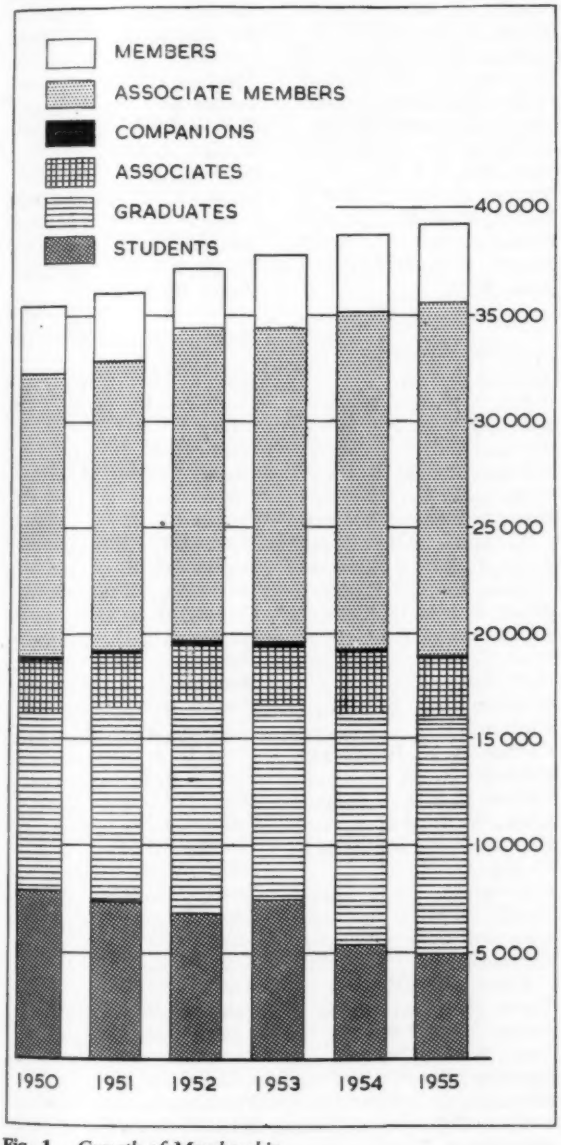


Fig. 1 *Growth of Membership*

mostly for transfer from one class to another, making a total of 4374. On the 1st April, 1955, there were 31 148 Corporate Members and Graduates on the Register representing 79·3% of the total membership of 39 298. For the first time the total number of Corporate Members exceeds 20 000.

The number of Graduates increased during the year to 11 153 (10 717 in 1954), and when their practical training and responsible experience in their profession are of the required standard, they will qualify for transfer to the class of Associate Members.

Nearly 200 candidates attended for interview by representatives of the Council and thus were enabled to explain personally the degree of responsibility which they were undertaking. The Council decided that the fee of £4 previously charged to such candidates should be abolished as from the 1st January, 1955.

The Council have been concerned at the fall in the number of applications for Student membership, and the report of a special Committee set up to study the problem is now being considered.

The changes in membership since the 1st April, 1954, are shown in Appendix A, and the growth for the last 15 years in Appendix B. Fig. 1 shows the growth of membership of the various classes during the last six years.

2 Honorary Members

The Council take great pleasure in recording that they have elected the following to Honorary Membership of The Institution:

On the 6th January, 1955, acting under Bye-law 10(*a*), Mr. J. R. Beard, C.B.E., M.Sc., Past-President, for his distinguished services to the profession, more especially in the field of the transmission and distribution of electricity and for his valuable services to The Institution.

On the 3rd February, 1955, acting under Bye-law 10(*b*), His Royal Highness the Duke of Edinburgh, K.G., P.C., K.T., G.B.E., F.R.S. The interest which His Royal Highness has long displayed in science and engineering and their applications gave additional pleasure to the Council in making this election.

3 Faraday Medal

The thirty-third award of the Faraday Medal has been made to Sir John Cockcroft, K.C.B., C.B.E., M.A., M.Sc.Tech., Ph.D., F.R.S., Member, Director of the Atomic Energy Research Establishment, Harwell, for the conspicuous services he has rendered to the advancement of electrical science, and for his distinguished work in the field of nuclear physics and the development of power from nuclear sources.

4 Principal Honours and Distinctions Conferred on Members

Baron

GRIDLEY, SIR ARNOLD B., K.B.E., M.P. (Member).

Knight Commander of the Order of St. Michael and St. George

NICHOLLS, MAJOR-GENERAL L. B., R. SIGNALS, C.B., C.B.E. (Member).

Commander of the Order of the British Empire

DAW, COLONEL S. E. H., O.B.E. (Associate).
GOLDUP, T. E. (Member).
GREEN, E. H. R., M.SC. (Member).
MANNING, F. E. A., M.C., T.D., B.SC.(ENG.) (Member).
MELLING, C. T., M.SC.TECH. (Member).

PASK, V. A. (Member).
SMITH, PROFESSOR C. HOLT, M.SC. (Member).
WATSON, ALFRED, B.SC. (Member).

Officer of the Order of the British Empire

CONNOR, R. (Associate Member).
DUCKWORTH, H. (Member).
MATTHEWMAN, PROFESSOR T. H. (Member).
NIXON, CMDR. (L) W. I., R.N. (Associate Member).
PHILIP, P. (Member).
ROBERTS, V. W. M., B.SC. (Associate Member).
SACKEY, E. A. (Associate Member).
VOWLES, G. A. (Member).
WYNN, COLONEL A. H. (Associate Member).

Member of the Order of the British Empire

CARY, R. H. J. (Associate Member).
CRITCHLOW, V. G. (Associate Member).
CROSS, CAPTAIN H., M.C. (Associate Member).
GANN, W. T. (Member).
GRIBBIN, MAJOR K. D., R. SIGNALS, B.A. (Associate Member).
PEDDLE, H. L. (Associate Member).
ROSTRON, F. (Member).
WASSER, H. E. (Associate Member).

Territorial Decoration

SEARLE, K. A., M.SC.(ENG.) (Associate Member).

Army Emergency Reserve Decoration

COOPER, MAJOR J. A. (Associate Member).
COPE, LT.-COL. W. J. L. (Associate).
MITCHELL, LT.-COL. M., M.B.E., B.SC.(ENG.) (Associate Member).
RICHMOND, LT.-COL. F. A., R.E. (Associate Member).
WEAIRE, MAJOR R. F. A., R. SIGNALS (Associate Member).
WILKINSON, MAJOR E. H., M.C. (Associate Member).

5 Deaths

The Council record with regret the deaths of the following members of The Institution:

Honorary Member

Kennedy, Sir John M., O.B.E.

Members

Ackerley, R. O.
Albertus, C. V. G.
Anderson, A.
Bremner, D. A., O.B.E.
Brocklesby, H.
Burford, G. G.
Carnegie, H. S.
Constable, A. D., O.B.E.
Cooper, A. B., B.Sc.(Eng.).
Cridge, A. J.
Crum, T. G., B.Sc.(Eng.).
De Valbreuze, R.
De Wardt, R. G., C.B.E.
Dixon, H.
Dobson, Lt.-Col. J. H., D.S.O., D.Eng., D.Sc., M.Sc.
Emanuel, C. W.
Eve, J. L.
Falshaw, R.
Foyster, A. H., M.B.E.
Furse, W. F.
Gillett, J. K., M.Sc.Tech.
Grace, G. E.
Grime, R. E., M.Sc.
Hadley, A. E., C.B.E.
Hammett, A. T.
Hancock, Group-Captain G. N., R.A.F., C.B.E.
Hinings, F. S. G.
Hippisley, E. T., M.A.
Horsfall, W. M.
Hoult, W., B.Sc., M.Eng.
Jenkins, I. H.

Members—continued

Jobbins, G. G.
Johnston, A.
Lea, R. H. M., C.B.E., B.E.
Lockton, C. P., M.Sc.Tech.
Lucking, E. P.
Macrory, R. V., M.B.E.
Marsh, W.
Mawdsley, J. H. St.H.
Mayson, C. M.
Mirrey, J., B.Sc.
Morgan, W. D. N.
Nicholls, F.
Nimmo, H., C.B.E.
Nixon, L. R., M.Sc.(Eng.).
Noble, K. J.
Ockenden, F. E. J.
Palairet, C. R.
Parker, W. A. H.
Pinder, P. M.
Procter, F. E., M.B.E.
Scott, W. A.
Sharp, E. E.
Shephard, T. F. G.
Simpson, Sir Maurice G., C.S.I.
Solomon, H. G.
Solomon, M.
Speight, A., I.S.O.
Stevens, T., M.E.
Stewart, C. L E.
Tsirimokos, A. M., B.Sc., Ph.D.
Turnbull. C.
Turner, E.
Turner, P. W.
Walker, H. W.
Warwick, J.
Webb, J., C.M.G., C.B.E., M.C.
Weston, G. C.
Whipp, I. T. L.
Wood, W. J. H.

Associate Members

Allwood, S. J. R.
Astley, J. W.
Atkins, F.
Austin, G.
Balshaw, J. O.
Bayly, C. F. H.
Bennett, Lieut.-Col. M. C., R. Signals, O.B.E.
Bland, F. W.
Bloome, J.
Bluett, E. J. H.
Brotherton, C. E.
Buck, C. L. F.
Burbridge, W.
Burslam, J. A.
Campbell, E.
Cannon, A. H., B.E.E.
Cartlidge, R.
Chilton, F. E.
Clark, W. Brindley.
Connor, F. G., B.Sc.(Eng.).
Cooper, G. W.
Crabtree, F.
Crellin, H. M.
Cummins, C. J.
Czarniecki, F. K., Ph.D. (Eng.), M.Sc.(Eng.).
Davey, R. B.
Davis, E. W., B.Sc.
Dean, S. M., B.Sc.
Dempsey, J.
Dixon, E.
Dobbie, C. L.
Dove, W. E. B.
Edes, Lt.-Col. N. H.
Edmonds, H. T. G.
Edwards, E. A.
Elliston, E. R.
Evans, H. M.
Evans, W. E.
Ford, C. H.
Freeborn, K. L. C., B.Sc. (Eng.).
Gardiner, R., B.Sc.Tech.
Gheury de Bray, M. E. J.
Gilliver, S. F. J.
Gillman, E. P.
Goward, F. K., M.A.
Greenhalgh, E.
Greenslade, C. E.
Grigsby, B. J.
Hardey, J. E.
Hargreaves, T.
Hawkins, H. J.
Hiscock, A. G.
Hodgson, W. G.
Horn, D. J.
Howell, A. H. L.
Hunt, T. C., M.C.
Jackson, J. W.
Johnstone, E. A.
Jolliffe, V. N.
Jones, I. G., B.Sc.
Jones, I. L.
Jones, J. C.
Keen, H. E.
Korn, A. M. G.
Lakeman, B.
Lamerton, A. H.
Lefroy, Lt.-Col. H. P. T., D.S.O., M.C.
Lumsden, J. H.
McCulloch, A. F., B.Sc.Tech.
McDougald, F. M.
Macewan, J. E.
McKay, A. H.
Mandal, S. N.
Maquay, G. A.
Markes, A. S.

Associate Members—continued

Master, R. J.
Matthews, R.
Maurice, R. B.
Meetens, R. G.
Millar, I. P.
Milne, A.
Molloy, V. L.
Moss, G.
Mudford, Captain J. F. W., R.N.(Retd.).
Mullowney, J.
Newbery, A. F.
Orange, W. J.
Orr, Prof. J., O.B.E., LL.D., B.Sc.
Padgham, F. V.
Rowe, J. A. V., M.C.
Russell, L. W. G.
Shipton, K. H., B.Sc.(Eng.).
Spencer, E. D.
Stewart, B. G.
Stiling, A. J.
Swainsbury, Lt.-Cmdr. (A) H., R.N.V.R.
Tatton, E.
Thompson, W. B.
Tisdall, H. G.
Trimmer, W. J.
Turner, Cmdr. C. W. C., R.N.(Retd.).
Walker, D. B.
Ward, F. R.
Waters, Major G., R.E., B.Sc.(Eng.).
Wellingham, Col. H. J., M.C., T.D.
Whyte, R. P.
Wilson, C. H.
Wingett, A. W.
Wright, C. H.

Companions

Rea, The Hon. J. R., M.A.
Sinclair, A.

Associates

Allcock, W.
Bailey, A. C.
Cole, H. J. C.
Collins, C. E.
Evans, T. E.
Finding, W.
Fowler, G. V.
Holmes, R. H.
Hunter, T. C.
Kearney, W. S.
Longmore, F. W.
McDonald, A.
O'Malley, C.
Pedder, R. S.
Petters, J. M.
Pulleyn, G.
Simpson, W.
Small, C. E.
Souter, J. S.
Swann, J. E.
White, J. H.

Graduates

Abba, H. A.
Boadle, R. K., B.E.
Davenport, R. A.
Denney, J. H.
Gaskell, A. S.
Gessey, J. T.
Molloy, R.
Moor, T. L.
Smith, R.
Smith, S., B.Sc.
Walker, J. A.
Wilson, R. S., B.A.

Students

English, P. F.
Fisher, J. F.
Hardy, B. W.
Owen, R. G.
Turnbull, W. D.
Willson, J. C. N.

6 Members who have Retired, or who are of Long Standing

During the year, 161 members took advantage of a rule, under which Members, Associate Members and Associates who have retired from the profession may apply to retain their membership without payment of further subscriptions, provided that they have reached the age of 60 and have had 25 years' continuous membership. A comparable rule applies to Companions, who must have reached the age of 70.

Seventy-seven members qualified for a total remission of subscription under a rule covering members of any class who have completed 50 years' membership.

7 Professional Conduct

The Council regret that it has been necessary for them to remove the name of an Associate Member from the Register under the provisions of Bye-law 41(*a*).

8 Unauthorized Use of Membership Initials

The Council have continued their firm action in all cases of the unauthorized use of membership initials which are brought to their notice, and during the year have obtained satisfactory undertakings and apologies from sixteen offenders.

The Council will be glad if members will bring the facts of any doubtful cases to the attention of the Secretary.

9 The Designation "Chartered Electrical Engineer"

By a note in the *Journal* and in other ways the Council have emphasized that a wider use of the title "Chartered Electrical Engineer" would help towards a greater understanding on the part of the public of the professional status of Corporate Members of The Institution.

SECTION B Institution Activities

10 Meetings

During the 12 months ended 31st March, 1955, 1 292 meetings of the members, the Council and the various Committees were held in London and at the Local Centres. A detailed statement is given in Appendix C, and Fig. 2 shows the number of meetings held during the past six years. Twelve Ordinary Meetings were held in London, with an average attendance of 314 as compared with 256 for the previous year. A joint meeting with The Institution of Civil Engineers, three Extra Meetings, and the Annual General Meeting were also held.

A public meeting was held at the Central Hall, Westminster, London, for the delivery of the 1954–55 Faraday Lecture by Mr. T. B. D. Terroni, B.Sc., Member (see par. 21).

The 45th Kelvin Lecture on "The Physics of the Ionosphere" was given in the Lecture Theatre of The Institution by Mr. J. A. Ratcliffe, O.B.E., M.A., F.R.S., Member.

Reference to the meetings of the four Specialized Sections and the Informal Meetings of The Institution is made in subsequent paragraphs.

11 Specialized Sections

The Council are at present reviewing the scope of the Specialized Sections, paying particular attention to the organization of the light current and radio fields and taking into account the fields covered by the Technical Committees on Electrochemistry and Electrometallurgy, Telegraphs and Telephones, and Traction.

The membership of the Sections continues to grow; particulars of this growth and of the activities of the Sections are summarized below. Fig. 3 shows the membership of the Sections for the past six years.

	Membership at 31st March, 1955	Number of meetings	Average attendance (figures for last year in brackets)
Measurements Section	2442	14	65 (87)
Radio Section	5037	17	134 (165)
Supply Section	4328	10	157 (139)
Utilization Section	4149	8	112 (95)

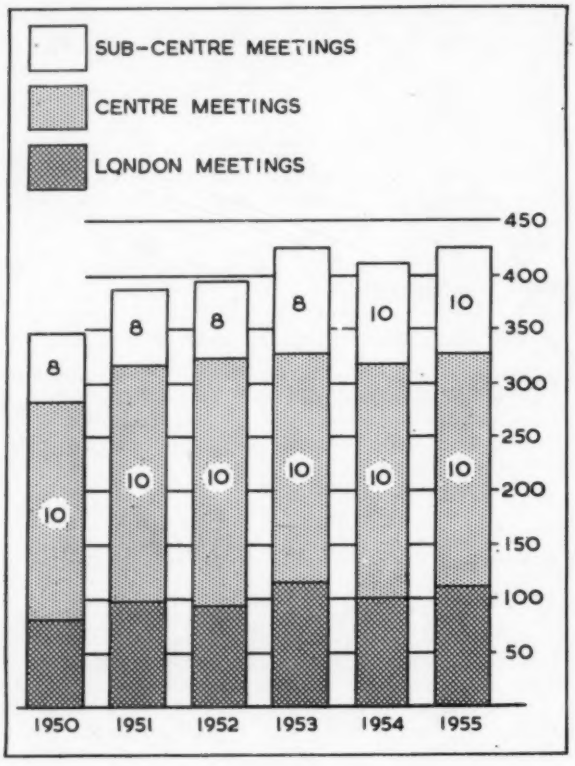


Fig. 2 *Total number of Meetings held in London and in the Centres and Sub-Centres*

The numerals 8 and 10 indicate the number of Centres and Sub-Centres. In 1953 the federated Scottish Centre was formed, and meetings since then have been held under the aegis of the three Sub-Centres in Scotland.

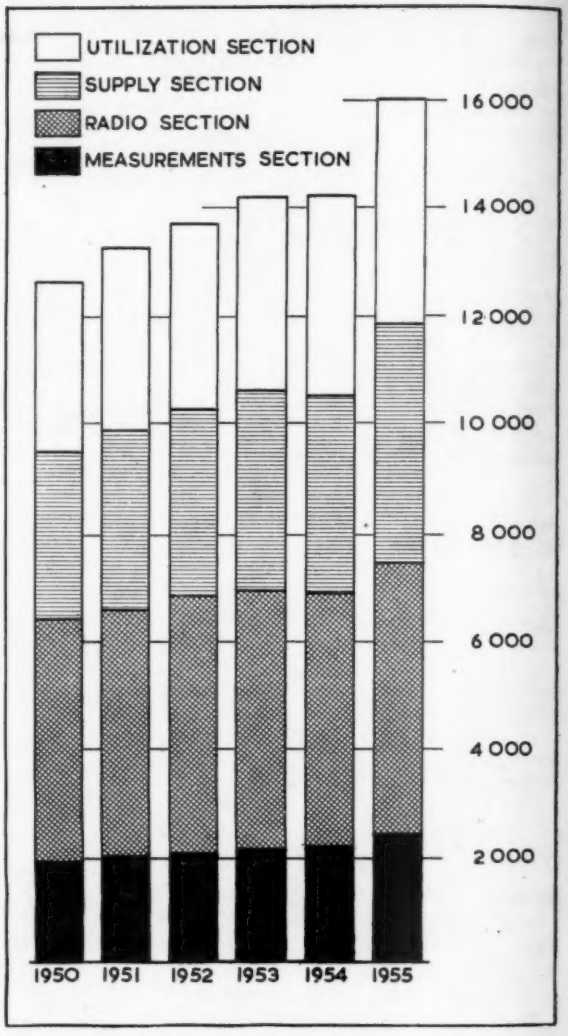


Fig. 3 *Membership of the Specialized Sections*

Measurements Section

The Measurements Section Committee again express their satisfaction at the very considerable number of papers submitted for their consideration. During the year they have examined the MSS. of about 80 papers, some of which have been accepted for reading, and others, on account of their mathematical or academic content, for publication only. The new arrangement under which all papers whose subject-matter is in the light-current field which are accepted by the Committee are now published in Part B of the *Proceedings*, with those of interest to the Radio Section, has met with general approval. The programme has included papers on high precision measuring and recording instruments, on servo systems and mechanisms, and on the measurement of magnetic materials and semi-conductors. Four Discussion Meetings have also been held, of which two were devoted to considerations affecting personnel and instruments in atomic energy projects.

The Committee were pleased to receive a request from the Société Belge des Ingénieurs des Télécommunications et d'Électronique to participate in an International Meeting on Analogue Computing to be held in Brussels in the autumn of 1955, and have secured promises for twelve papers.

The Annual Lecture was delivered on the 11th May, 1954, by Dr. K. J. R. Wilkinson, Member, his subject being "Measurement as a Factor in Understanding."

The Summer Visit took place on the 11th June, 1954, when members of the Section inspected the British Railways Locomotive Testing Station at Rugby, while the ladies visited Rugby School. Lunch was taken at Kenilworth, and afterwards the complete party toured the Works of Cadbury Bros. at Bournville.

The Annual Dinner was held at the Café Royal, London, on the 9th November, 1954, at which 260 members and their guests were present. The Section again joined with the Radio Section in a very successful Dinner-Dance also held at the Café Royal on the 30th March, 1955.

With the approval of the Council, the Section Committee, in collaboration with the D.S.I.R. Advisory Committee on High-Speed Calculating Machines, are making arrangements for a Convention on Digital Computer Techniques to be held in April, 1956.

Radio Section

During the year under review the Radio Section held 17 meetings. The programme was varied and comprised, in addition to the Opening Meeting, eight Section meetings devoted to the presentation of papers, four Discussion meetings and four Informal Lectures. The Section Committee also sponsored the meeting held in Celebration of the Jubilee of the Thermionic Valve (see par. 12).

Eighty-seven papers have been submitted to the Committee for consideration, an increase of twelve on the number considered last year.

The Summer Visit was held on the 10th July, 1954, when a party of more than 200 members of the Section and their guests spent a very enjoyable day at Portsmouth. The Section Soirée was held on the 29th November, 1954, when there was an attendance of over 450. In addition to many interesting exhibits and demonstrations, those present were invited, by kind permission of the B.B.C., to attend a performance of "What Do you Know?" which was recorded in the Lecture Theatre. The concluding social event of the year took the form of a Joint Dinner-Dance with the Measurements Section at the Café Royal on the 30th March, 1955.

Supply Section

Because of the increase in the number of papers accepted for reading the Supply Section had to arrange two additional meetings. Further, five Supply Section papers have been read at Ordinary Meetings. This record has been reflected in the award of two of the three major premiums to Supply Section papers.

Two outstanding lectures have been delivered. On 26th May, 1954, Mr. Philip Sporn, Member, spoke on "Electrical Power Demand and Supply in the United States and the Role of Research in the Quarter Century Ahead," and on the 23rd February, 1955, the Section were privileged to hear Mr. Åke Rusck lecture on "High-Voltage Transmission Developments in Sweden," and to see the first showing of a film on High-Voltage D.C. Transmission.

The total number of papers received by the Committee was 27, of which twelve were accepted for publication only.

A feature of the year has been the support received for the Section's social events. Day visits to the Atomic Energy Research Establishment at Harwell on the 7th May, 1954, and to the Television Studios and Centre at Lime Grove and the White City on the 30th April, 1955, have been heavily oversubscribed. Two Dinner-Dances have been held at the Café Royal, the first on the 8th April, 1954, being attended by 257 members and guests, and the second on the 22nd March, 1955, by 286 members and guests.

The annual week-end Summer Visit was held at Cambridge from the 16th to 19th September, 1954, and was attended by 183 members and guests. The Committee are now completing arrangements for a visit to Holland in September, 1955.

Utilization Section

Twenty-two papers were received by the Committee during the year under review, compared with 14 last year. Five of these were accepted for reading at Section Meetings and nine were accepted for publication only.

There was a marked increase in the membership of the Section, and the eight meetings held were well attended. As is now customary, one meeting was devoted to the reading of three short papers prepared by members of the Students' Sections.

The Annual Lecture entitled "Fuel Supplies of the Future" was delivered by Mr. D. Hicks on behalf of Mr. E. F. Schumacher of the National Coal Board who was indisposed.

The Summer Visit was held at Stratford-upon-Avon on the 28th–29th May, 1954. Members and their ladies attended a performance of "Romeo and Juliet" at the Shakespeare Memorial Theatre on the Friday evening after which they were shown behind the scenes. On the following morning the members visited a colliery near Coventry, whilst the ladies were shown round Charlecote Manor. In the afternoon the whole party visited Warwick Castle.

The Third Annual Dinner-Dance was held at the Café Royal on the 19th January, 1955, and was attended by a total of 145 members and their ladies.

Arrangements are in hand for the holding early in 1956 of a Symposium on Electrical Equipment of Aircraft.

12 Celebration of the Jubilee of the Thermionic Valve

On the 16th November, 1954, The Institution celebrated the Jubilee of the Thermionic Valve at a meeting held 50 years from the date on which Professor Ambrose Fleming patented his diode. The proceedings were opened by the Lord President of the Council, the Marquess of Salisbury, K.G., P.C., and there followed three lectures. The first on "The Genesis of the Thermionic Valve" was given by Professor G. W. O. Howe, D.Sc., LL.D., Member, and was followed by a lecture on "Thermionic Devices from the Development of the Triode up to 1939" by Sir Edward Appleton, G.B.E., K.C.B., M.A., D.Sc., LL.D., F.R.S., Hon. Member. In the evening a concluding lecture by Dr. J. Thompson, M.A., D.Sc., Member, was given on the subject of "Developments in Thermionic Devices since 1939."

During the week in which the Jubilee was celebrated an Exhibition was staged at The Institution which showed the developments from the original Fleming diode to the travelling wave tube of the present day. The exhibits were borrowed from 20 different sources for the occasion.

The opening address and the lectures are to be published in book form in the spring of 1955 and in this volume will be incorporated a complete list of all the associated exhibits.

13 Informal Meetings

Informal Meetings continue to play an important part in the activities of The Institution and the keen interest of members in the wide variety of subjects discussed has been evidenced by the good attendance at the six meetings held.

As their title implies, the proceedings at these meetings are entirely informal, and no reports are published in the *Proceedings* or elsewhere.

14 Local Centres and Sub-Centres

On the 1st January, 1955, 17 381 members were attached to the ten Local Centres as follows:

East Midland	1 118	North-Western	2 888
Mersey and North Wales	1 232	Scottish	1 707
North-Eastern	1 304	South Midland	3 317
Northern Ireland	274	Southern	1 533
North Midland	1 799	Western	2 209

Programmes of meetings framed to suit particular local interests were arranged by the Committees of these Centres and the ten Sub-Centres, some meetings of a general character being held in all. In addition a number of social functions

have been held, several of which were attended by the President. Each Centre and Sub-Centre has also received a visit from one of the Vice-Presidents.

A petition from members in Cambridgeshire, Norfolk and Suffolk seeking the Council's authority for the formation of an East Anglian Sub-Centre was submitted through the Committee of the East Midland Centre and was approved by the Council. The new Sub-Centre will commence activity in October, 1955, and will provide regular meeting facilities for some 500 members; previously facilities have been provided through the activities of the Cambridge Radio Group and also by the District Meetings which for some years past have been held at Norwich and Ipswich.

During the year the following Honorary Secretaries of Centres and Sub-Centres have tendered their resignations:

Mr. A. V. Milton, Associate, Mersey and North Wales Centre, after nine years of service.
Dr. T. G. Bridgwood, B.Sc., Associate Member, North Midland Centre, after four years of service.
Mr. R. H. Phillips, Associate, South Midland Centre, after four years of service.
Mr. E. S. Johnson, Associate Member, North Staffordshire Sub-Centre, after four years of service.

The Council take this opportunity of recording their deep appreciation of the services which these Officers rendered to The Institution.

The Specialized Groups have continued to provide for the interests of local members of the Specialized Sections and have received encouragement from the visits which were paid to them by the Chairmen of the Sections.

The Annual Conference of Honorary Secretaries of Local Centres and Sub-Centres was held in London to coincide with the Annual Dinner of The Institution. The Conference took place over two days and a long agenda gave these Officers an opportunity to discuss matters of common interest relating to their work for The Institution.

15 District Meetings

District Meetings in increasing numbers have been held throughout the country wherever membership of The Institution is too scattered to justify the provision of more formal local activities. The informality of this type of meeting is undoubtedly a great attraction and it is true to say that many members who otherwise would have had little opportunity of attending a meeting of The Institution, have been able to take part in the discussion of Institution papers.

16 Students' Sections

Although as already noted the membership of the Students' Sections has again fallen there is no evidence that this has resulted in a further decline in attendances at meetings, as compared with the previous year. In fact, there has been encouraging support for a number of meetings, particularly the Students' Lectures delivered by Dr. E. C. Cherry, Associate Member, on "Communication of Information—Human, Animal and Machine," and Mr. A. R. Cooper, M.Eng., Member, on "Attitudes of Mind." A feature of both these lectures has been the excellent discussions to which they have given rise.

Unfortunately the proposed Summer Meeting in Northern Ireland in 1954 had to be cancelled because of lack of support and it has been agreed that no more Meetings of this kind should be organized until there is a clear demand for them.

There has been one addition to the number of Students' Sections during the session, the North of Scotland Students' Section having been officially constituted in June, 1954. Students' Section meetings are also being held in the areas of the North Lancashire and the South-Western Sub-Centres, and also in the Irish Oversea Branch.

A Conference of Honorary Secretaries of Students' Sections was held in November, 1954.

17 Students' Quarterly Journal

The *Students' Quarterly Journal* has been maintained at its recently increased size of 64 pages. No difficulty has been experienced in finding suitable material for the expanded publication, which continues to be widely read, not only by Graduate and Student members, but also by a number of senior members.

The June, 1955, issue will be the centennial number, completing 25 years of continuous quarterly publication.

18 Oversea Activities

The activities of the Oversea Branches and Committees have been maintained and so far as local conditions would allow meetings, visits and social functions have been arranged for the interest of local members. Several senior members, who have had to travel abroad, have addressed meetings of members and have thereby strengthened the links between The Institution at home and members oversea.

A number of oversea members have called at Headquarters during the year, some 150 having signed the Oversea Register. The Secretary would like to take this opportunity of reminding oversea members who have occasion to visit London that he and his staff will be glad to advise and help them in any way that they can.

A number of members of The Institution took up oversea appointments during the year. Most of them have carried letters of introduction to the Executive Officers of the National Engineering Societies of their new countries of residence and have received much valued help and guidance.

Details of the arrangements being made in Canada for joint meetings between members of The Institution and members of the Engineering Institute of Canada will be found in par. 52.

During the year under review the following Oversea Representatives have been appointed by the Council:

Victoria and Tasmania: Professor C. E. Moorhouse, M.E.E., Member (in place of the late Mr. F. E. J. Ockenden).
Natal: Mr. R. M. O. Simpson, Member (in place of Mr. C. Kinsman).

19 Annual Dinner

The attendance at the Annual Dinner each year continues to increase and a record total of almost 1400 members and guests attended the function this year which was held at Grosvenor House, London, on the 24th February, 1955.

The Rt. Hon. Sir Raymond Evershed, Master of the Rolls, was the principal guest and proposed the toast of "The Institution," to which the President replied. The toast of "Our Guests" was proposed by Mr. Harold Bishop, C.B.E., B.Sc.(Eng.), immediate Past-President, and the reply was

given by The Rt. Hon. Lord Citrine, K.B.E., Chairman of the British Electricity Authority.

A full account of the function appears in the May, 1955, issue of the *Journal*.

20 Summer Meeting

At the invitation of the Chairman and Committee of the Western Centre, a Summer Meeting of The Institution was held in the area of the Centre on the 28th June–2nd July, 1954. An account of the meeting, which was attended by 257 members and ladies, was published in the August, 1954, issue of the *Journal*, and the warm thanks of The Institution have been expressed to all those who contributed so much to the enjoyment of the members and their ladies.

At the invitation of the Chairman and Committee of the Scottish Centre, arrangements are being made to hold a Summer Meeting in the Highlands of Scotland from the 6th to 11th June, 1955.

21 Faraday Lecture

The Faraday Lecture, which this year carried the title of "Courier to Carrier in Communications," was delivered by Mr. T. B. D. Terroni, B.Sc., Member, at public meetings held in Liverpool, Rugby, Hull, Nottingham, Birmingham, Manchester, London, Swansea, Bristol, Leeds, Edinburgh, Dundee and Belfast. Additional lectures were given before audiences of senior school-children in Nottingham, Birmingham and Edinburgh in conjunction with the Local Education Authorities. In many cases the audiences, which were composed in the main of members of the general public, totalled 2000; Mr. Terroni thus addressed between 25 and 30 thousand people during the course of 16 lectures.

22 Committee on Electrical Exhibitions

The Committee (which is convened by the Council and includes members nominated by the British Electricity Authority, the Area Electricity Boards, the British Electrical and Allied Manufacturers' Association and the Cable Makers' Association) have continued to maintain close touch with the authorities of the Science Museum, South Kensington, for the setting up of a new electrical power collection.

In addition to the substantial financial contributions which have already been received from the bodies mentioned above, the project has been supported by offers from particular manufacturers to supply individual exhibits needed to complete the collection. Negotiations with the Government concerning the architectural finish of the gallery in the museum which is to house the Collection have recently been brought to a successful conclusion, and the work of preparing and staging the exhibition is being pressed forward.

The Committee are collaborating with the museum authorities in the presentation, at the time of the I.E.C. Meetings in London in June, 1955, of a special exhibition on the theme of "Electrical Measurement."

23 Exhibitions of Outstanding Scientific Interest

The Secretary is at all times pleased to receive details, for submission to the Exhibitions Committee, of new developments of scientific interest suitable for exhibition under this scheme, which provides facilities for the display in the Institution building of exhibits dealing with such developments. Subjects which have been shown recently or are in active preparation are:

Progress in line amplifiers for telecommunication.
Developments in oscillators for telemetry.
A new radar sonde.
Measurement of current in a remote conductor by a magneto-optical effect.

24 The Organization and Government of The Institution

The organization and government of The Institution is dependent on the links that exist between the Council and the many Committees at home and oversea that are keystones in The Institution's structure.

In wider fields, The Institution plays its part by representation on a large number of bodies having objects cognate with its own, the individual nominations being made by the Council from among the members of The Institution. A list of the bodies on which The Institution is represented has been published in the *Journal* (February, 1955).

SECTION C Technical Investigations

25 Codes of Practice

From 1943 to 1954, Codes of Practice dealing with electricity in buildings (numbered in the 320 series of Codes) were drawn up by a Committee convened by the Council of The Institution on behalf of the Council for Codes of Practice for Buildings set up under the aegis of the Ministry of Works. Twenty-three such Codes were published. Eight other Codes (numbered in the 1000 series of Codes) were prepared under an agreement between the three Engineering Institutions and the British Standards Institution and seven further Codes were in draft. In each instance the British Standards Institution was responsible for publication.

The Minister of Works having indicated that his Department could no longer assist financially the work of drafting Codes for buildings, a new Council for Codes of Practice within the framework of the British Standards Institution, and having the status of a Divisional Council, was formed with the support of the professional Institutions. In April, 1954, this Council assumed responsibility for both the above series, as well as for the work of the Civil Engineering Codes of Practice Committee.

The new Codes of Practice Council has set up a Codes of Practice Committee for Electrical Engineering under the Chairmanship of Mr. P. V. Hunter, C.B.E., Honorary Member, the secretariat for which is provided jointly by the British Standards Institution and The Institution. The existing Code drafting Committees now report to this Committee and their secretariat servicing is shared between The Institution and the British Standards Institution as previously, The Institution retaining responsibility for all the electrical Codes for buildings. Codes dealing with radio interference abatement are referred to in par. 26.

The following Codes have been approved for promulgation:

General aspects of radio interference suppression.
Safety lighting and primary-maintained lighting in cinemas.

(In the last instance liaison is maintained with the Home Office regarding reference to Statutory Regulations.)

Approval of the following Code for promulgation is expected shortly.

Street lighting (Part II, Roads other than traffic routes) (C.P. 1005, Part II).

The drafting of the following Codes is proceeding:

Earthing (preliminary draft in preparation by the E.R.A.).
Maintenance of electrical switchgear (to be based on B.S. 1086).
Overhead electric power lines.
Selection and installation of electric cooking equipment for schools.
Use of Electronic Valves, Part III, consisting of:
Section 6: Additional recommendations for photocells.
Section 7: Additional recommendations for transmitting valves.
Section 8: Additional recommendations for cold-cathode gas-filled valves.
Section 9: Additional recommendations for magnetrons.
Section 10: Additional recommendations for special-quality valves.

The partial or complete revision of the following Codes is under consideration:

C.P. 321: Electrical installations—general (to await completion of 13th Edition of Wiring Regulations).
C.P. 325: Farm and horticultural electrical installations (a revised clause dealing with electric fences has been drafted).
C.P. 327.101: Telephones and telegraphs—public services.
C.P. 327.201: Broadcast reception—sound and television by radio.

Contact continues to be maintained with Oversea Representatives of the Council and Secretaries of Oversea Branches and Committees, to whom new Codes and drafts are circulated.

26 Committee on Radio Interference

The Committee have drawn the attention of interested bodies to the need for exploratory work on the probable needs of interference abatement in the higher frequency bands now about to be put into wider use, and the matter is being followed up. A survey of likely demand for measuring equipment in this range has been made and the outcome has been reported to the Engineer-in-Chief of the Post Office. An attempt is also being made to estimate how far the seriousness of interference with television reception from ignition systems of internal-combustion engines has been reduced by voluntary action as well as by the effect of Statutory Instrument No. 2023, of 1952, which relates to new vehicles. The interest which a number of organizations, as well as the Press, continue to take in the abatement of interference from internal-combustion engines, is welcomed.

The activities of a number of Sub-Committees convened jointly by The Institution and the British Standards Institution who are examining various technical issues—one of which deals with relations with the special international Committee on Radio Interference (C.I.S.P.R.)—have continued to receive the support of the Committee. The Committees dealing with Codes of Practice, which report to the Committee on matters of policy and to Technical Committee ELE/32 of the British Standards Institution on matters of standardization, now come under the aegis of the newly-formed Codes of Practice Committee for Electrical Engineering ELCP/– (see par. 25).

The advice of the Committee continues to be available to the Postmaster General on any matters within their purview which may arise (see par. 32).

27 Committee on Regulations for the Electrical Equipment of Aircraft

The revised Section J—Electrical, of the British Civil Airworthiness Requirements, issued on 1st June, 1953, continues in force, and during the session the problems of power supply regulation, particularly in relation to valve heater supply, have received study.

Liaison is maintained with the Aircraft Radio Equipment Committee (see next par.) and with the British Standards Institution. A number of draft British Standards for aircraft electrical apparatus have been scrutinized.

28 Committee on Radio Equipment for Civil Aircraft

The revised Section R—Radio, of the British Civil Airworthiness Requirements, promulgated on 1st April, 1953, continues in force, and during the Session the problems of valve heater supply in relation to power system regulation have been studied with a view to amendments to Sections R and J of the Airworthiness Requirements. These, if adopted, would enable the use of regulators to be dispensed with in certain circumstances. Contact is maintained with the Code Drafting Committee on the Use of Electronic Valves, who are drafting further parts of C.P. 1005.

Liaison is maintained with the Aircraft Electrical Committee (see preceding par.) in regard to power supply, and regarding the proposed revision of British Standard G.100 "General requirements for electrical equipment and indicating instruments for aircraft," which is cited in Sections R and J. A number of draft British Standards for telecommunication apparatus have been scrutinized.

29 Model Forms of General Conditions of Contract

A new Model Form E—Home Cable Contracts—with Installation, prepared by the Model Forms of Contract Committee of The Institution, was published in October, 1954, after approval by the Council.

Model Form B.3—Export, including delivery and erection on site, which was drawn up by the Joint Model Forms of Contract Committee of The Institution and The Institution of Mechanical Engineers, was published in May, 1954, after approval by the two Councils.

The Drafting Sub-Committee of the Joint Committee have under consideration a complete draft of a new Form B.1—Export Contracts for the delivery f.o.b. or c.i.f. of electrical and mechanical plant, which will shortly go before the parent Committee for approval. Export contracts f.o.b., including supervision of erection, are to be dealt with in a further Model Form (B.2), instead of in an addendum to Form B.1 as previously envisaged. The preparation of a short version of Form B.1 (B.1.SF.) has been proposed and is under consideration. A proposal remains to be considered that the range of Model Forms for export should be completed by the preparation of a Model Form B.4—Export, delivery f.o.b., with erection on site.

In the range of Model Forms for home contracts, a Panel of the Joint Committee are engaged in the revision of Model Form C (1940)—Home, with erection.

30 Study Committee on Basic Design Temperatures for Space-Heating Installations

The Study Committee was set up in April, 1950, on the invitation of the Minister of Works, by the Councils of The Institution of Mechanical Engineers, The Institution of Electrical Engineers, The Institution of Gas Engineers, and The Institution of Heating and Ventilating Engineers, Sir David Brunt, M.A., Sc.D., F.R.S., being appointed Chairman.

Its report, which makes proposals for a method of selection of basic design temperatures related to the type of structure of the building concerned and the climatic history of the locality, has been received by the Council and was approved for transmission to the Minister in July, 1954, similar action having been taken by the other sponsors. The Report will, it is understood, be published shortly by Her Majesty's Stationery Office in the series "Post-War Building Studies."

31 Wireless Telegraphy Act, 1949

The Wireless Telegraphy Act, 1949, provides in Section 9 for the appointment by the Postmaster General of a Panel of persons nominated by the President acting with the approval of the Council, and for the appointment by the President, with the approval of Council, of two expert assessors to assist the President of the Tribunal set up under the Act.

During the year Mr. J. W. Stevenson was appointed to fill the vacancy on the Panel caused by the death of Mr. Frank Gratwick. The services of Sir Noel Ashbridge, B.Sc.(Eng.), Past-President, and Mr. H. W. Grimmitt, Member, as assessors continue to be available.

32 Postmaster General's Advisory Committees on Ignition Systems, Refrigeration Apparatus and Small Motors

From the Panel referred to above the Postmaster General has appointed Advisory Committees as provided in the Wireless Telegraphy Act, the secretarial work for which is carried out jointly by the Post Office and The Institution.

The Wireless Telegraphy (Control of Interference from Ignition Apparatus) Regulations, 1952 (S.I. No. 2023, 1952), were laid before Parliament on the 27th November, 1952, and came into operation on the 1st July, 1953.

On the basis of the Reports of the Advisory Committees on Refrigeration Apparatus and Small Motors respectively, the Postmaster General has now made the following Regulations which were laid before Parliament on 1st March, 1955:

S.I. No. 291, 1955, The Wireless Telegraphy (Control of Interference from Electric Motors) Regulations, 1955.
S.I. No. 292, 1955, The Wireless Telegraphy (Control of Interference from Refrigerators) Regulations, 1955.

The former relates to small motor-driven appliances which cause interference while in use, whilst the latter relates to new refrigerators when placed on sale. In a Press release the Post Office drew attention to the advice of the Advisory Committees regarding the need for earthing, particularly where capacitor suppressors were used.

33 Economic Commission for Europe: Working Party on International Forms of Contract for Heavy Engineering Equipment

Ten sessions of the Working Party have been held in Geneva since its formation in 1951.

On the nomination of the Councils of The Institution of Mechanical Engineers and The Institution of Electrical Engineers, H.M. Government appointed Mr. J. F. St.G. Shaw, B.Sc.(Eng.), Member, to serve as one of the U.K. delegates to the Eighth and subsequent Sessions of the Working Party. Messrs. K. F. A. Johnston and H. B. Morton, B.A., Member, continue to serve.

The above-named are members of both the Joint Committee with The Institution of Mechanical Engineers and The Institution's own Committee on Model Forms of General Conditions of Contract.

34 Extra-Mural Committee on the Application of Electricity to Industrial Process Heating

The Extra-Mural Committee on the Application of Electricity to Industrial Process Heating, of which Sir John Hacking, Past-President, is Chairman, provides the British link with the International Committee on Electro-Heat.

Its terms of reference are "to discuss, co-ordinate and foster activities likely to advance the application of electricity to industrial process heating and to report from time to time to the Council of The Institution of Electrical Engineers."

SECTION D Joint Activities with Other Bodies

35 Co-operation between Engineering Institutions

Close collaboration has continued between The Institution, The Institution of Civil Engineers and The Institution of Mechanical Engineers, in order to ensure effective co-operation in matters of common interest to their members. The three Presidents, following well-established practice, have met frequently to exchange views and thus to secure unity of action where appropriate on matters of common concern.

In the special field of engineering education, the three Presidents have had the advice and support of the Joint Advisory Committee on Education.

36 Parliamentary and Scientific Committee

After an approach by the officers of the Committee to the three Presidents, the Council, in common with the Councils of the other two Engineering Institutions, have agreed to accept membership of the Committee in a consultative capacity without voting powers.

Alterations to the constitution of the Parliamentary and Scientific Committee have been adopted and a new category of Associated Members has been introduced having the characteristics described above. An application for membership in this class has been lodged by the Council and has been accepted.

The Parliamentary and Scientific Committee provides a meeting-place for Members of Parliament on the one hand and representatives of the pure and applied sciences on the other, and while of an unofficial character has performed useful service in emphasizing the scientific viewpoint in relation to matters of national concern.

37 The Technology of Nuclear Energy and its Applications

The Council have supported discussions between representatives of the three Engineering Institutions, The Institution of Chemical Engineers and The Institute of Physics on the steps which should be taken jointly by these societies to provide a channel for the publication of technological information on the development of nuclear energy in Great Britain.

As a result specific proposals for the setting up of a group, perhaps to be known as "The British Nuclear Energy Conference," are under consideration which will co-ordinate the work of the adhering societies in the technology of nuclear energy to ensure an ordered programme of meetings, a few of which would be joint meetings, and also to provide a jointly produced journal in which the principal British advances in the field would be recorded.

38 Graham Clark Lecture

During the year, the Councils of the three Engineering Institutions adopted a proposal emanating from the three Presidents for the establishment of a joint lecture on a cultural subject allied to engineering to be held annually at each of the three Institutions in turn. The Lecture, which is to be known as the Graham Clark Lecture, will commemorate the work carried out for the three Institutions by Mr. E. Graham Clark, the late Secretary of The Institution of Civil Engineers. The first Lecture is being sponsored by The Institution of Civil Engineers and will be held at that Institution on Wednesday, 4th May, 1955, when Sir Harold Hartley, K.C.V.O., C.B.E., M.C., F.R.S., will deliver a Lecture on "The Engineer's Contribution to the Conservation of Natural Resources."

39 Committee of Inquiry into the Organization and Efficiency of the Electricity Supply Industry in England and Wales

In reply to an invitation to give evidence to this Committee the Council of The Institution indicated that, while not feeling competent or wishing to express an opinion on the efficiency and organization of the Electricity Supply Industry in England and Wales, they would be pleased to offer their views on certain related matters such as the education, training and recruitment of technical personnel; the research activities of the industry; and the measures it adopts for the publication of scientific information. Learning that this course would be welcome, the Council have transmitted in confidence to the Committee of Inquiry a memorandum dealing with these subjects.

40 British Council

The work of the British Council has continued to receive support, in particular through the service of Mr. T. G. N. Haldane, M.A., Past-President, on its Science Advisory Committee, and of the Secretary on its Science and Engineering Panel.

Contact is maintained with the Science and Engineering and Visitors' Departments of the British Council to ensure that persons visiting this country under its auspices, whose interests lie in the field of electrical engineering, are given the opportunity of visiting The Institution for discussions and to take part in its technical activities.

In response to a request, advice has recently been offered to the British Council on the most effective means of disseminating knowledge in South America of the achievements of British engineering.

41 British Standards Institution

Association with the work of the British Standards Institution has been maintained. Particulars of the Council's representation on the Engineering Divisional Council, the Electrical Industry Standards Committee, the Telecommunication Industry Standards Committee, the Illumination Industry Standards Committee and many Technical Committees dealing with British Standards were published in the *Journal* (February, 1955).

The preparation of Codes of Practice is dealt with in par. 25.

The British National Committee of the International Electrotechnical Commission is dealt with in par. 51.

42 Electrical Research Association

The support of The Institution for the work of the British Electrical and Allied Industries Research Association continues. Professor J. Greig, M.Sc., Ph.D., Member, and Mr. A. W. Montgomery, O.B.E., B.Sc.Tech., Member, serve on its Council as the nominees of the Council of The Institution.

43 Professional Engineers Appointments Bureau

The Council's interest in the operation of the Bureau has been maintained and their representatives continue to serve on the Board of the Bureau and on its Electrical Engineering Committee. The Bureau has been active in making nominations to supply vacancies and in other ways, and in particular its advisory services were extensively used by engineers and employers on a number of matters relating to employment.

44 Technical and Scientific Register, Ministry of Labour and National Service

The Electrical Engineering Advisory Committee, under the Chairmanship of Sir Arthur P. M. Fleming, C.B.E., D.Eng., Past-President, have considered a progress report prepared by the Electrical Engineering Section of the Register and other matters of importance to the work of the Register.

The number registered in the Electrical Section is approximately 517 and of this number fewer than 130 are actually unemployed. The Council again appeal to employers not to insist upon too low an age when submitting particulars for vacancies.

45 Engineers' Guild

With the Councils of the other two Institutions and of the Engineers' Guild, the Council have approved the setting up of a Joint Consultative Committee of the four organizations having the following terms of reference:

> To consider matters of common concern to the three Institutions and to the Engineers' Guild and to report as necessary to the respective Councils.

46 National Inspection Council for Electrical Installation Contractors

Submission of the final report of the Organizing Committee convened by the British Electricity Authority to put forward recommendations for a National Inspection Council for Electrical Installation Contractors, a draft of which had been approved by the Council in May, 1952, was deferred while the views of one of the organizations on the Committee as to its terms were awaited. It has recently been learned that support by the bodies represented on the Organizing Com-

mittee is now unanimous, and since the Council's approval of the proposals had been reaffirmed, inauguration of the new Inspection Council may be expected shortly.

47 British Electrical Power Convention

The Council's support of the British Electrical Power Convention continues. Mr. T. G. N. Haldane, M.A., Past-President, has recently been succeeded by Mr. R. W. Mountain, Member, as The Institution's representative on the Council of the Convention, with the Secretary as deputy.

48 Conference of Commonwealth Engineering Institutions

As reported in the December, 1954, issue of the *Journal*, the Conference met in London from the 24th May to the 4th June, 1954. Representatives from six Commonwealth countries and from the three home Institutions were present at its eleven sessions. The Conference findings were expressed in sixteen Recommendations dealing with matters of common concern to the Constituent Institutions in carrying out the objects for which they were incorporated. These have been received and ratified by the Councils concerned, except for three Recommendations which the Council of one Constituent Institution has not accepted; their reasons have been made known and will be discussed at the next meeting of the Conference which is to be held in Australia in 1958, The Institution of Engineers, Australia, acting as hosts.

Among Resolutions dealing with matters of domestic concern to the Conference was one admitting the Rhodesian Institution of Engineers to membership.

From the remarks of the visiting delegates and subsequent correspondence it is clear that the Conference was of great value, and that its business sessions and the social programme which was arranged have left a deep impression.

49 EUSEC—Conference of Representatives from the Engineering Societies of Western Europe and the United States of America

As agreed at the third meeting of the EUSEC Conference held in Paris in September, 1953, the next meeting will take place in Copenhagen in September, 1955, the Danish Institution of Engineers acting as hosts. Among other matters the Conference will then take into consideration a report from the EUSEC Conference on Engineering Education (see par. 68) recommending the setting up of that Conference as a separate and continuing organization.

50 Commonwealth/EUSEC/UPADI Conference, Brussels

A meeting took place in Brussels in June, 1954, of representatives from the Commonwealth, EUSEC and UPADI Conferences. The meeting was held at the invitation of the Société Royale Belge des Ingénieurs et des Industriels and followed immediately on the meetings of the Commonwealth Conference in London (see par. 48). The third organization represented is the Pan-American Federation of Engineering Societies and is the counterpart in the Americas of the other two Conferences.

The interchange of views which took place on a number of common problems affecting the activities of the member societies of the three Conferences was very valuable. The joint Conference also took note of the outcome of discussions held under EUSEC auspices concerning the relations of EUSEC with the International Federation of National Engineering Associations (FIANI).

51 International Electrotechnical Commission

The Jubilee of the I.E.C. was celebrated in September, 1954, in Philadelphia, the then President-Elect being present as the special representative of The Institution.

Four members of the British National Committee of the I.E.C. are nominated by the Council, and are chosen so that the aspects of illumination and telecommunication, as well as electrical engineering generally, are represented.

The Council also support the work of the I.E.C. through the service of their nominees on corresponding B.S.I. Committees, and in particular by authorizing the Committee on Regulations for the Electrical Equipment of Ships to act on the invitation of the British National Committee as the United Kingdom Committee for matters concerning I.E.C. Technical Committee No. 18—Electrical Installations in Ships (see par. 82). Plenary meetings of Technical Committee No. 18 were held at the time of the Philadelphia celebrations and as a result agreement was reached on a draft I.E.C. Code of Recommended Practice for Electrical Installations in Ships, which will shortly be circulated to the member nations for consideration and approval, under the established I.E.C. procedure. The holding of a series of I.E.C. Meetings in London in June for which the British National Committee are the hosts is welcomed, and arrangements are in hand for suitable hospitality to be extended by The Institution to the delegates.

52 Engineering Institute of Canada

After discussions which took place when Sir John Hacking, as President, with the Secretary, visited Eastern Canada in 1952, increasing collaboration has taken place between The Institution and the Engineering Institute of Canada in the provision of programmes of interest to electrical engineers, particularly in Toronto, and the possibility of arranging similar meetings in other parts of Canada is being actively explored.

The Council support the policy adopted by all members of the Commonwealth Engineering Conference, that a professional engineer's first allegiance should be to the national engineering society of the country in which he resides, taking membership of another Institution more concerned with his speciality only if he finds he needs additional support in this regard. In pursuance of this policy the Council have recently entered into arrangements with the Engineering Institute whereby the entrance fees of candidates who in all other respects have satisfied the requirements of the Bye-laws may be waived if at the time of their election they are members in good standing of the other Institution. Under the arrangements the first application for election must be made within twelve months of taking up residence.

53 Commission Mixte Internationale

Mr. P. J. Ryle, Member, continues to act as the Council's representative on the Commission Mixte Internationale, which is concerned with studies for limiting the interaction of power and telecommunication systems.

54 International Commission on Illumination (C.I.E.)

The Council continue their support of the C.I.E. through their adherence to the National Illumination Committee of Great Britain. Under the constitution of this Committee, The Institution, as one of the three sponsoring bodies, fills one of three seats on its Committee of Administration.

55 International Commission on Irrigation and Drainage

The Institution's support of this new Commission has been maintained, and the Council's representative, Mr. G. R. Peterson, B.A., Member, continues to serve on the Commission's British National Committee.

Its second Congress was held in Algiers in April, 1954, and publication of the Congress transactions is expected shortly.

SECTION E Education

56 Education and Training

The Education and Training Committee have met eleven times during the year and have discussed a number of major topics. Matters of educational policy which were of common interest to the three Engineering Institutions have been examined by the Joint Advisory Committee on Education, the constitution of which was reported last year, and representatives drawn from this Committee have acted as delegates on a number of occasions during the year.

Further discussions have taken place relating to the proposed new national award. The outcome of these discussions has unfortunately revealed apparently irreconcilable differences between the views of the Engineering Institutions and those of the National Advisory Council on Education for Industry and Commerce.

The introduction of works-based sandwich diploma courses has been welcomed by the larger units of industry and provided that their introduction is restricted to major colleges, they should receive adequate support from industry. The small firms will undoubtedly find some difficulty in allowing their student apprentices to participate in these courses and in many cases they will continue to support the system of part-time education through the National Certificate scheme.

Consideration was given to the problem of training marine electrical engineers to meet the requirements resulting from increasing complication of electrical equipment in ships. A letter was sent to the Minister of Transport expressing the views of the Council on this matter.

The current shortage of textbooks has been studied by a special Panel; their recommendations, which the Council have accepted, are recorded in par. 69.

The importance of the problem of increasing recruitment to the electrical engineering profession is fully recognized. Among a number of measures which have been put in hand an analysis is being carried out of the number of places in electrical engineering departments of universities in the United Kingdom and the extent to which they are being filled. Furthermore, The Institution is participating in careers exhibitions and has accepted invitations to give advice to pupils and their parents at a number of schools. A careers booklet is being prepared which will be liberally illustrated by photographs of a wide range of engineering activities. A film to be called "The Inquiring Mind" is being produced for showing to the senior boys at the public and grammar schools, to encourage boys—particularly those who might not contemplate a scientific career—to consider the opportunities offered by a career in electrical engineering. It is expected that both the booklet and the film will be available for general use from the beginning of the next school year.

Further discussions took place with the Secretary of State for the Colonies regarding the education of engineers in Colonial Territories, with particular reference to West Africa, as a result of which a statement was issued by the Secretary of State confirming that he would encourage faculties of engineering science in universities and that The Institutions on their part would co-operate in advising him on these matters.

57 Technological Education

During the year discussion has taken place in the Education and Training Committee and in the Joint Advisory Committee on Education of the three Institutions on the educational facilities which should be provided to increase the number of boys being educated as engineers and the nature and conditions of the proposed new award which would be nationally acceptable as the hall-mark of a sound technological education.

In the early part of the year, a meeting took place between representatives of the three Institutions and of the Technological Sub-Committee of the Parliamentary and Scientific Committee. This meeting revealed a considerable measure of agreement between the two parties on general principles, though there were significant differences of opinion on matters of detail.

Discussions have also taken place with Sir Ronald Weeks and members of the National Advisory Council on Education for Industry and Commerce, at the request of the Minister of Education. These discussions led to the preparation of a document by the Institutions which set out a scheme which the Institutions would be prepared to support in an effort to bridge the gap between their recommendations and those of the National Advisory Council. The latter considered this document and presented to the Institutions their further views which proved wholly unacceptable as they still revealed major differences of principle between the two. The main questions at issue were concerned with the insistence by the Institutions on three main points:

(1) At the outset only a small number of colleges in which the necessary standards could be assured should be recognized for the new courses and awards and that the present limited teaching resources should be concentrated in them.
(2) That the control of conditions leading to the new award should be in the hands of those who were professionally qualified to adjudicate.
(3) That the award in engineering should have a title which was readily distinguishable from that used for secondary technologies, to avoid the risk of confusing the public by the existence of varying academic standards.

Further reconciliation between the two points of view now appeared to be impossible and the new Minister of Education was faced with a serious gap between the maximum compromise on the part of the Institutions and the views held by the National Advisory Council.

A meeting was held between the Joint Advisory Committee on Education and representatives of the Royal Institute of Chemistry, the Institute of Physics, the Institution of Chemical Engineers and the Institution of Metallurgists, in which the original views of the three Institutions received full support.

The scientists felt, however, that excessive concessions had been made to meet the views of the National Advisory Council in the later proposals and that they would not support a scheme with this degree of compromise.

The Minister of Education received representatives of the Institutions in February, 1955, and in spite of the unanimity of view expressed by the professional, scientific and technological Institutions, he appears, at present, to find the views of the National Advisory Council for Industry and Commerce more acceptable.

58 Examinations

The Examinations Committee have, in the course of eleven meetings, agreed the criteria to be applied to Degree, Diploma and National Certificate Courses for which recognition is granted as accepted educational qualifications under the Institution Examination Regulations that were published in September, 1953. The Committee have deliberated, in conjunction with the Education and Training Committee, upon the features to be sought in works-based Sandwich Diploma Courses and have given preliminary consideration to the approval of colleges for the provision of courses in preparation for Part III of the Institution Examination.

The Council have approved a revision of conditions under which candidates with degrees in Physics, General Science and Mathematics may be admitted to The Institution. An alternative avenue has been provided for election as Associate Members where subsequent training and responsible experience has shown that the candidate has been able successfully to apply his basic education to the problems of electrical engineering. Details of the Council's decision are being published in the *Journal*.

With the assistance of their Sub-Committee for Educational Qualifications, who have met 13 times, the Committee have made substantial progress towards the preparation of a revised edition of the Schedule of Accepted Educational Qualifications, having approved a number of home and oversea Degree and Diploma Courses together with many National Certificate Courses, for exemption from the appropriate sections of the Institution Examination.

Model Examination Papers for Parts II and III of the revised Institution Examination were published in May, 1954, and a Laboratory Syllabus in September, 1954. A List of Books suitable for the Examination is in course of preparation.

59 The Institution Examination

In 1954 the Part I Examination, conducted jointly with The Institution of Civil Engineers, replaced the Section A Examination in accordance with the revised form of the Institution Examination. During the year the Council, together with the Council of The Institution of Civil Engineers, welcomed the reconstitution of the Joint Part I Committee whereby The Institution of Mechanical Engineers became a partner in the conduct of the Examination, the responsible committee being renamed The Engineering Institutions' Examination (Part I) Committee. A new constitution was later approved by the Councils of all three Institutions permitting the admission of other engineering institutions into the Part I Examination scheme. It has also been decided that a new compulsory subject "Engineering Drawing" should be added to the syllabus. Applications from other institutions to join the scheme have been received and are now under consideration by the Councils of the three Institutions.

Candidates of The Institution of Mechanical Engineers will be admitted to the Part I Examination for the first time in April, 1955, and the Examination will entirely replace that Institution's Section A Examination in April, 1957.

The Institution Examination was held in April and October for candidates in the British Isles, in April for oversea candidates in the northern hemisphere and in October for candidates in the southern hemisphere.

	April, 1954		*October, 1954*	
	Number of centres	Number of candidates	Number of centres	Number of candidates
Home Centres (including the Republic of Ireland)				
Part I	17	175	15	120
Section B	13	129	12	111
Technical Colleges (English only)	150	4481	45	260
Oversea Centres				
Part I	28	380	19	56
Section B	21	267	20	118
H.M. Forces	7	7	2	2

The figures for the Part I Examination include only those candidates seeking membership of The Institution. The Joint Examination in English which is held at technical colleges throughout the United Kingdom is open to all students following courses leading to the award of National Certificates in Civil, Mechanical, Electrical, Production, Gas or Mining Engineering. The figures for technical colleges include all students who are following courses leading to National Certificates in any of these branches of engineering.

60 Theses

During 1954 ten candidates submitted theses for consideration in satisfaction of the educational requirements of The Institution, and seven of these were accepted. The corresponding figures for the previous year were eight theses submitted of which three were accepted.

61 Common Preliminary Examination

The purpose of the Common Preliminary Examination is to set a minimum standard of general education to be reached by all candidates for Student Membership. The majority of candidates possess a School Certificate, a General Certificate of Education or some other qualification accepted for exemption from the Common Preliminary Examination, but a small number are required to take it.

The examination is administered by the Engineering Joint Examination Board, on which the principal Engineering Institutions are represented. It is held twice yearly, in April and October, both at home and abroad. During the year under review 44 candidates for membership of The Institution were examined at home and 103 abroad, compared with 70 and 161, respectively, in 1953.

62 National Certificates and Diplomas in Electrical Engineering

In the conduct of courses in Electrical Engineering and the award of National Certificates and Diplomas, The Institution has been associated with the Ministry of Education (England and Wales), the Scottish Education Department and the Ministry of Education (Northern Ireland).

The following figures relate to the number of courses in operation during the past two years:

	Number of courses		Certificates and diplomas awarded	
	1953	1954	1953	1954
England and Wales	594	670	7635	8085
Scotland	46	48	496	554
Northern Ireland	13	14	95	73

The National Certificate Scheme continues to provide a sound technician education for a large number of candidates who go no further than the Ordinary National Certificate level and for senior technicians who complete the Higher National Certificate Course, and it is expected that they will continue to serve this purpose even whilst the new technician courses are developing because of their established national recognition.

The number of candidates who obtain exemption from the Institution Examination through the Higher National Certificate with the necessary endorsement certificates is likely to decrease since, after the session 1956–57, it will be necessary in addition to the present requirements, to pass Part III of the Institution Examination thus lengthening the course to be undertaken by part-time study. Many such students, particularly those employed by larger undertakings, are likely in future to attend sandwich diploma courses as a normal avenue to a professional qualification with concurrent practical training.

63 Page Prize

The Page Prize, which takes the form of textbooks or instruments to the value of five guineas, is awarded each year to the candidate who is adjudged as having the best performance in final examinations of the Higher National Certificate in Electrical Engineering. For 1954 the Council decided that the award should be made to two candidates of outstanding performance, Mr. David John Matthews of the Stafford County Technical College, and Mr. Douglas Soutar of the Paisley Technical College. Both prize winners were evening-class students.

64 Joint Committee on Practical Training

The Joint Committee on Practical Training in the Electrical Engineering Industry have met twice during the year and have continued their preparation of a revised Report on the Practical Training of Professional Electrical Engineers. A separate panel has been set up to enquire into the requirements for the practical training of electrical engineers by student and graduate apprenticeships in research organizations. The Joint Committee have also prepared a short memorandum on Vacation Training which has now been published.

The Joint Committee have been very sorry to lose the valued services of Sir Arthur P. M. Fleming, C.B.E., D.Eng., LL.D., Past-President, as the result of his decision to relinquish his membership. Sir Arthur Fleming had served as Chairman since the Joint Committee was set up in 1945.

65 Scholarships

There have been two meetings of the Scholarships Committee during the year under review. The number of candidates for Institution Scholarships showed a small increase compared with the previous year and the Committee interviewed 13 candidates for Student Scholarships and seven candidates for the Research and Graduate Scholarships. Particulars of the successful candidates were published in the *Journal* (October, 1954).

A special award for a student wishing to pursue a works-based sandwich diploma course has been established by the Council and has been named The Arthur Fleming Scholarship to commemorate Sir Arthur Fleming's life-long interest in the education and training of persons employed in the electrical engineering industry. Changes have also been made to the general conditions of award of Student Scholarships and the special conditions of award of the Paul Scholarship so that additional scholarships may be available, when required, for students wishing to follow a sandwich diploma course.

66 Education in the Colonies

As the result of discussions with the Secretary of State for the Colonies regarding the education of engineers in Colonial Territories, a measure of agreement was reached and the following statement was made by the Secretary of State:

The Secretary of State has discussed with representatives of The Institutions of Civil, of Mechanical and of Electrical Engineers the provision of technological education in Engineering in the Colonies with special reference to West Africa. The Secretary of State informed the Institutions' representatives that he would encourage, as far as is compatible with University autonomy, the establishment at the earliest practicable moment of Faculties of Engineering Science in Universities and University Colleges in Colonial Territories.

The three Institutions for their part undertook to co-operate in advising on the standards of education and training which would be regarded by them as appropriate for admission to Student Membership of The Institutions, whether courses of study are taken in Universities or in Technical Colleges. Successful students will be considered on their merits for election or transfer to higher grades of membership on the same basis as all other candidates.

The Institutions, though recognizing that conditions vary in different Territories, nevertheless expressed the hope that the above principles would be applied in due course throughout the Colonial Territories.

67 Courses for Electrical Technicians

A second Conference on Courses for Electrical Technicians was held in July, 1954, to consider proposals for a basic course for electrical technicians together with detailed syllabuses for the first three years of a five-year course. These proposals formed the Interim Report of a Committee which was set up by the Council to study the general pattern which technician courses might follow and to prepare syllabuses covering basic education and specialized applications. A request that the Council should undertake this work was made at an earlier Conference on Technicians which was held in June, 1953. More than 50 delegates attended the second Conference, including representatives of the Ministry of Education, Regional Advisory Councils for Further Education, B.E.A.M.A., the Radio Industry Council, and the City and Guilds of London Institute.

As a result of suggestions made at the conclusion of the Conference, the City and Guilds of London Institute are developing a scheme of examinations for electrical technicians on the lines recommended by The Institution, and are also engaged on the preparation of syllabuses for the second and specialized part of the course. Their proposals will be submitted in due course to the Council's Committee with the intention that a comprehensive report on courses for electrical technicians should be prepared and published. Meanwhile the Council have authorized the publication of an Interim Report on the work of their Committee.

68 EUSEC Conference on Engineering Education

Attended by delegates from eleven countries whose professional engineers adhere through their national bodies to the EUSEC Conference, a second special Conference on the Education and Training of Professional Engineers was held in Zürich from the 27th September to the 1st October, 1954. The Conference, which included in each delegation representatives of universities and industry, set up two Working Parties, one to prepare a glossary in the different languages of the member Societies, of terms relating to engineering education and training, the second to analyse on a comparative basis the general education received in the various countries by a student before he began his engineering education.

The Conference resolved to recommend to EUSEC that a third Conference on Engineering Education and Training should be held, and an Executive Committee was set up to prepare for this Conference, on which the Council is represented by Dr. Willis Jackson, D.Sc., F.R.S., Vice-President.

69 Technical Publications

Reference has been made in previous reports to the Council's concern over the shortage of suitable textbooks on electrical engineering, particularly specialized textbooks of post-graduate standard. A report of the Education and Training Committee on this subject has been approved by Council and the Committee have now set up a Technical Publications Panel to carry out their recommendations. The Council have accepted the suggestion that in certain circumstances The Institution should be prepared to assist financially with the publication of suitable textbooks; authority has also been given for the establishment of an "Institution Series" of such books.

The Technical Publications Panel are considering the needs of both undergraduate and advanced students and they are also reviewing those textbooks which have become out of print and might deserve republication. Their efforts so far have resulted in authors undertaking the writing of two advanced textbooks and the rewriting of an out-of-print textbook of undergraduate level.

70 Rationalized M.K.S. System of Units

The use of the rationalized M.K.S. system of units is steadily gaining acceptance in the teaching of electrical engineering, and in the opinion of the Council it would be useful and convenient for a concise table or set of tables to be published setting out side by side the rationalized and unrationalized values of the fundamental electrical and magnetic units, and a selection of the fundamental equations which are in common use also in their rationalized and unrationalized forms.

In view of the widely recognized international position of the British Standards Institution in the field of international standardization, the Council have suggested that they might be willing to undertake the publication of a set of tables to meet this need.

71 Education Discussion Circle

The Education Discussion Circle have held eight meetings during the session including a Joint Meeting with The Institution of Mechanical Engineers and the Institute of Physics. In addition an exhibition of apparatus for teaching electrical engineering was arranged at Battersea Polytechnic in June, 1954, and was attended by 130 members.

All the meetings of the Education Discussion Circle are informal. They are usually attended by teachers and others interested in exchanging views on matters connected with the teaching of electrical engineering but all members of The Institution are welcome. The average attendance at meetings during the session has continued to be about 50.

Education Discussion Circles are also a regular part of the activities of the South Midland and North Midland Centres. There have been five meetings at the former and four at the latter Centre with average attendances of 41 and 12 respectively.

The North Midland Circle usually meets in Leeds but during this session meetings have also been held at Bradford and Batley.

72 Advisory Service on Education and Training

Student and Graduate members as well as new entrants to the profession continue to make use of the Advisory Service on matters concerning the education and training required of a professional electrical engineer. In addition the facilities available are used regularly by Government departments such as the Ministry of Labour and National Service and the Colonial Office. Members of the Panel, consisting of a number of senior representatives of The Institution in the main industrial centres in the country, have also been available when required to interview candidates experiencing special difficulties.

73 Receptions for Oversea Graduates

Each year the Council have welcomed at a reception in the Institution building graduates who have come for training and advanced study in this country under the Athlone Fellowship Scheme. In 1954 the invitation was extended to include F.B.I. scholars as well as graduates who had come to this country by private arrangement for training with individual firms or advanced study at universities. Altogether 120 graduates from 24 different countries attended this year's tea-time reception which was held in September, 1954. The visitors were received by the President and were afterwards entertained by members of Council and the London Students' Section Committee in the Library. This was followed by an address by the President in the Theatre and a programme of films selected for their interest to oversea visitors.

The Council also acted as hosts at an evening meeting in January, 1955, which formed part of the F.B.I. Oversea Scholars' Annual Reunion. This meeting was attended by nearly 100 visitors, including representatives of all three Engineering Institutions and of the F.B.I. Scholarship Committee. Dr. W. Abbott presented a paper on the "Training of Engineers in the United Kingdom," which was followed by a discussion and contributions from members of the three Institutions. The proceedings concluded with a buffet supper.

74 Lectures for Young People

"Nuclear Power—Electricity from Uranium" was the subject of this year's Christmas Lecture, which was delivered by Dr. T. E. Allibone, D.Sc., F.R.S., Member. The lecture, which was presented on the afternoons of the 30th and 31st December, 1954, was outstandingly successful. More than 1 000 schoolchildren were present at the two lectures.

In addition the Faraday Lecture by Mr. T. B. D. Terroni, B.Sc., Member, on "Courier to Carrier in Communications" was repeated, with the support of the Local Education Authorities, in Nottingham, Birmingham and Edinburgh before large audiences of senior schoolchildren.

SECTION F Institution Library and Publications

75 Library

The main collection contains nearly 9000 books, over 11000 volumes of periodicals, reports, etc., and several thousand pamphlets. Over 500 current periodicals are being received.

The following statistics indicate the additions to the Library during the year, the use made of the Reference Library by members and non-members, and the extent of borrowing from the Lending Library. Figures for 1953 are shown for comparison.

Reference Library

Year	Additions to the Library				Readers	
	Books		Pamphlets			
	Presented	Bought	Presented	Bought	Members	Non-members
1953	187	130	1200	144	7094	555
1954	90	189	1182	101	6631	604

Lending Library

Year	Books added to the Lending Library	Books issued	Borrowers
1953	152	4495	1515
1954	163	4412	1560

In addition, full use has been made of the facilities of the Science Library and Lewis's Library; the Science Library Photocopy Service has been used on 526 occasions. Particulars of the latter service have been published in the *Journal* (January, 1955).

76 Gifts to The Institution

In addition to the books and pamphlets which have been presented to The Institution (see previous paragraph), other gifts of manuscripts and objects of electrical engineering interest have been received from four members, to whom the Council have expressed their cordial thanks. Particulars have been published in the *Journal*.

An early Emitron camera mounted in a dignified showcase has been received from the E.M.I. Research Laboratories and is installed in the Faraday Room. This item is representative of the equipment used by the B.B.C. to begin the first high-definition television service in the world in 1936.

77 The *Journal* and *Proceedings* of The Institution

As announced in a Foreword in the July, 1954, *Journal* (p. 173) and in a leaflet circulated to members, the Council have adopted the two recommendations of a Panel appointed by the Papers Committee to review the arrangement of the *Journal* and *Proceedings*. The first recommendation was that the *Proceedings* should be rearranged in such a way that a reader would generally be able to find all the papers of interest in his field of work in a single Part; the second recommendation was that the *Journal* should be more attractive and less formal, while still appealing to all electrical engineers.

The way in which these recommendations have taken effect has been apparent to members since the early months of 1955. Previously all papers read at Ordinary Meetings were published in Part I (General) of the *Proceedings*, instead of Part II (Power Engineering) or Part III (Radio and Communication Engineering), even if they were Section papers, and all papers read before the Measurements Section were published in Part II, although some of them may have been of greater interest to radio engineers than to power engineers. Monographs were published in Part IV. The *Proceedings* is now divided into only three Parts, namely

Part A, Power Engineering
Part B, Radio and Electronic Engineering (including Communication Engineering)
Part C, Monographs

the principle adopted being that the content of a paper and not the meeting at which it was read, or the Section to which it was presented, determines the Part in which it is published. Thus Part A contains papers relating to power engineering in all its aspects, i.e. all Supply and Utilization Section papers and some Measurements Section papers; Part B contains all Radio Section papers and some Measurements Section papers. Part IV (Monographs) is succeeded by Part C, but Part I (General) has no successor, for most of the material which formerly would have appeared in Part I now appears in Part A or Part B. Duplicate publication will be avoided as far as possible, but a paper on, say, the inductive co-ordination of power lines and telephone lines would evidently have to be published in both Part A and Part B. Material such as the more abstruse kind of Kelvin Lecture will be treated as a Monograph and will appear in Part C.

The first number of the new *Journal* appeared in January, 1955. Both the cover of the *Journal* and its text pages have been completely redesigned, the average number of pages per issue has been increased, it is printed on thicker paper with a higher finish, and it is bound with a flat back similar to the binding of the *Proceedings*. The contents of the new *Journal* include nearly all the reference material that appeared in its predecessor; special articles on technical subjects, and on other subjects impinging on electrical engineering; Electrical Engineering Reviews, whose purpose is to provide all members with readable information on the present practice in specialized aspects of electrical engineering, and which have in general a narrower scope than the Progress Reviews in the *Proceedings*; correspondence on electrical engineering science or technology; and news of activities in the Centres and Branches of The Institution at home and oversea. The Council have aimed to make the contents of the *Journal* interesting and useful to all members of The Institution in whatever branch they are engaged. Members in general appear to approve of the new *Journal*; many letters about it have been received from them—without exception these were appreciative, and some contained constructive criticism. The Council do not consider that the new *Journal* is necessarily in its final form, and further changes will be made in it from time to time.

The *Journal* was—and is—supplied to all members, free of charge. Since January, 1955, it has been available to non-members at a price of 5s. per copy or an annual subscription of 25s. The number of non-members subscribing in March, 1955, was 1 080.

The numbers of members and non-members who subscribed for the four Parts of the *Proceedings* in 1954 are given below, together with the corresponding figures for 1953, for comparison.

	No. of pages		No. of members receiving copies		No. of non-member subscribers	
	1953	1954	1953	1954	1953	1954
Journal ..	400	332	All members		Not sold	
Proceedings:						
Part I ..	350	398	17 328	17 939	1 777	1 876
Part II ..	702	696	16 606	16 535	1 892	1 999
Part III	390	416	9 937	9 735	2 309	2 439
Part IV..	156	304	1 324	1 609	1 004	1 164
	1 598	1 814				

The numbers of papers published in the *Proceedings* during the five years 1950–54, and the average numbers for 1945–49, are shown graphically in Fig. 4. Addresses, lectures, progress reviews and reports are not included, nor are the papers which were published in special issues of the *Proceedings*, particulars of which were given in earlier Reports.

In 1954—the third year of their existence—30 Monographs appeared in Part IV of the *Proceedings*. That Part was published at irregular intervals; its successor, Part C, is to appear regularly twice a year, in March and September.

Paper, Reprint and Monograph Services.—A paper accepted for reading at meetings is, like a Monograph, first published individually and is republished in the *Proceedings* later. It was formerly considered necessary to use a special nomenclature to distinguish between a paper issued early, for which there is a small charge, and the same paper issued 10 days before the meeting or thereafter, for which no charge is made. Thus it was that papers published individually came to be known as "early proofs" or "meeting proofs." The term "proof," however, has turned out to be an unsuitable description for a document which, although subject to minor corrections, is republished in the *Proceedings* substantially as it stands. Since January, 1955, therefore, there has been no special nomenclature for papers which are accepted for reading at meetings. The announcements which appear month by month in the *Journal* and in a leaflet which is supplied to non-members who subscribe for the *Proceedings* but not for the *Journal*, distinguish clearly between a paper for which a charge is made and one that is supplied free, without calling it by any other name. The announcements also give full particulars of the Reprint and Monograph Services.

Bibliographical References.—A change has been introduced in the method of dating Institution papers to ensure that the time at which a paper was first published (i.e. as a "separate") is perpetuated when it is republished in permanent form in the *Proceedings*.

78 Premiums

The Premiums awarded by the Council for papers read at meetings, or accepted for publication only, will be announced in the *Journal* during the summer.

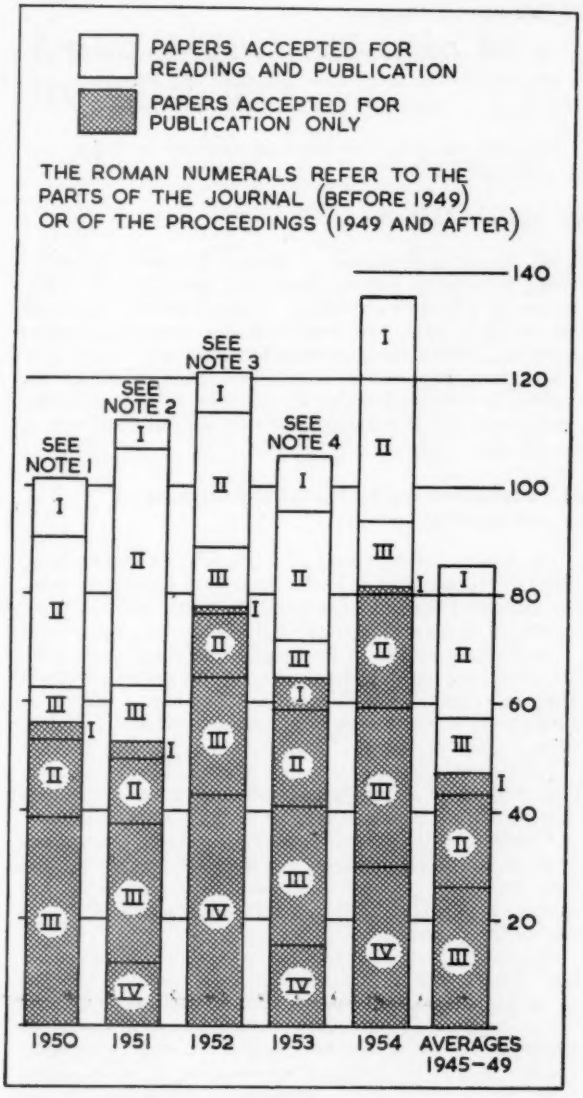


Fig. 4 *Numbers of papers published*

NOTES

1. 1950—Of the 12 papers accepted for reading and published in Part I, 4 were read at the Symposium on the M.K.S. System of Units. Of the 42 papers accepted for reading and published in Part II, 10 were read at the Symposium on Ferromagnetic Materials; the total number of papers read at that Symposium was 21, but 11 of them had already been published.
2. 1951—Of the 44 papers accepted for reading and published in Part II, 7 were read at the Symposium on Radiation Monitoring Apparatus; 7, at the Symposium on Electrical Meteorological Instruments; and 10, at the Conference on Electrical Instrument Design. Of the 12 papers accepted for reading and published in Part III, 3 were read at the Symposium on the Sutton Coldfield Television Station.
3. 1952—Of the 11 papers accepted for reading and published in Part III, 3 were read at the Symposium on Microwave Links.
4. 1953—Of the 10 papers accepted for reading and published in Part I, 3 were read at the Symposium on Nuclear Reactor Instrumentation. Of the 24 papers accepted for reading and published in Part II, 4 were read at the Symposium on Digital Computers.

79 Reviews of Progress

The following Progress Review was published in the *Proceedings* during the period covered by the Report:

Telephony and Telegraphy [Paper No. 1620, May, 1954 (101, Part I, p. 83)].

A Review on "The Utilization of Electricity in Ships" will be published shortly.

80 *Science Abstracts*

The size of each Section of *Science Abstracts* was maintained in 1954 at approximately the same level as 1953, *Section A* (*Physics*) containing 11 693 abstracts compared with 8 830 in 1953, and *Section B* (*Electrical Engineering*) containing 5 402 abstracts compared with 5 144.

The preparation of a cumulative 5-year index to the volumes of *Science Abstracts* for the years 1950–54 has been undertaken, and it is hoped that this may be published in the Summer, 1955.

81 Regulations for the Electrical Equipment of Buildings

The sale of copies of the 12th Edition of the Regulations, with 1954 Supplement and 1952 Temporary Relaxation inset, has continued steadily throughout the year and the total number of copies sold up to the 31st March, 1955, was 81 456.

An abridged version of the Regulations, issued in November, 1951, and dealing with work on site for single-family dwellings using single-phase supply, continues to prove useful, 9 936 copies having been sold up to the 31st March, 1955.

The Recommended Practice for Electrical Installations in Caravans, based on the Regulations, has also aroused much interest; 8 015 copies were sold up to the 31st March, 1955.

A second Abstract of Interpretations of the Regulations given to individual enquirers was released to the technical Press during the year and published in the *Journal* for September, 1954. The previous abstract was published in the *Journal* for September, 1952.

The preparation of the 13th Edition of the Regulations has been pressed forward, and when a proof has been reviewed by the Committee, the Council's approval to its promulgation will be sought. The close liaison established with the British Electricity Authority and Area Boards has been maintained, and the issue of the 13th Edition assumes particular importance in view of the recent agreement to establish a National Inspection Council.

Liaison continues to be maintained with the British Standards Institution regarding British Standards cited in the Regulations and a number of important draft Standards have been scrutinized from the aspects of safety from fire and shock.

82 Regulations for the Electrical Equipment of Ships

The Ship Regulations Committee, acting as the United Kingdom Committee of I.E.C. Technical Committee No. 18, completed in 1951 a preliminary draft of an I.E.C. Code of Recommended Practice for electrical installations in ships.

After circulation to National Committees of the I.E.C. for technical comment, the draft was considered at the meeting of I.E.C. Technical Committee No. 18 held in Philadelphia in September, 1954, and a revised draft is shortly to be circulated for approval. Certain matters still requiring attention are being reserved for a second edition and to deal with these the Committee will participate in a further meeting of I.E.C. Technical Committee No. 18 to be held in The Hague.

In the course of the I.E.C. work, matters relevant to the preparation of a 4th Edition of the Regulations for the Electrical Equipment of Ships have been noted and work is expected to proceed shortly.

SECTION G Benevolent Activities

83 Incorporated Benevolent Fund

The Report of the Court of Governors for the twelve months ended 30th June, 1954, together with the Accounts, was circulated with the September issue of the *Journal*; the report was subsequently published in the *Journal* (November 1954, p. 291). Subscriptions and donations showed a small increase from £12 155 to £12 427. This amount is insufficient, however, to cover expenditure and the Court appeal most urgently for help from the many members, in all some two-thirds of the membership, who at present make no subscription.

Although the standard of grants has been maintained, expenditure has shown an increase due to the extension of "The Chesters" Estate, the maintenance of which now costs approximately £2 000 per annum. To offset this, grants to beneficiaries who become residents on the estate are decreased or in some cases discontinued, and this has resulted in a saving of £750 a year.

Grants were made to 126 beneficiaries, and in assisting these persons the Fund also gave support to 101 of their dependants. The total amount of these grants was £8 845; the average amount distributed per beneficiary during the year was approximately £70.

In addition to the residential homes at West Worthing and Englefield Green, in which three of our beneficiaries are accommodated, the Crossways Trust has acquired a further property at Brighton, to which the Fund was invited to subscribe in units of £1 000, each unit giving the right to nominate a person for residence in the Home. Two units were subscribed and two of the Fund's beneficiaries have availed themselves of the opportunity of taking up residence in this Home. The original tenants selected in 1950 by the Court of Governors for the first group of eight houses on "The Chesters" Estate continue to enjoy their life there and the occupants of the second group of eight houses, completed in 1952, are also delighted with their homes in such pleasant surroundings.

The total amount received in subscriptions and donations from the inception of the Homes Fund to 30th June, 1954, was £33 873, and in addition 245 members have signed Deeds of Covenant for the payment of subscriptions for a period of seven years.

The Accounts of the Wilde Fund were published in the *Proceedings* (Part I, July 1954, p. 248).

SECTION H Institution Staff

84 The Staff

The Council express their sincere thanks to the Secretary and his staff for their work during the past year which has made possible the successful completion of the wide programme of activities carried out by The Institution. The traditional high standard of service has been fully maintained.

APPENDIX A

Membership of The Institution

The changes in the membership, since 1st April, 1954, are shown in the following table:

	Hon. Mem.	Mem.	Assoc. Mem.	Com.	Assoc.	Grad.	Stud.	Totals
Totals at 1st April, 1954 ..	13	3635	15904	80	2724	10717	5423	38496
Additions during the year:								
Elected	2	2	188	3	92	781	1132	2200
Reinstated ..	—	—	6	—	5	13	25	49
Transferred to ..	—	190	866	—	6	649	—	1711
Totals ..	2	192	1060	3	103	1443	1157	3960
Deductions during the year:								
Deceased ..	1	71	109	2	21	12	6	222
Resigned ..	—	6	35	1	29	62	98	231
Lapsed	—	2	37	1	34	129	791	994
Transferred from	—	—	190	—	25	804	692	1711
Totals ..	1	79	371	4	109	1007	1587	3158
Net change ..	+1	+113	+689	−1	−6	+436	−430	+802
Totals at 1st April, 1955 ..	14	3748	16593	79	2718	11153	4993	39298

APPENDIX B

Growth of Membership over the last fifteen years

Year (31st March)	Corporate Members	Non-Corporate Members	Total Membership	Annual Increase
1941 ..	10121	10154	20275	403
1942 ..	10483	10567	21050	775
1943 ..	11097	11218	22315	1265
1944 ..	11924	12634	24558	2243
1945 ..	12573	14091	26665	2107
1946 ..	13447	15711	29158	2493
1947 ..	14501	16759	31260	2102
1948 ..	15206	17701	32907	1647
1949 ..	16027	18344	34371	1464
1950 ..	16648	18900	35548	1177
1951 ..	17146	19412	36558	1010
1952 ..	17757	19496	37253	695
1953 ..	18510	19272	37782	529
1954 ..	19552	18944	38496	714
1955 ..	20355	18943	39298	802

APPENDIX C

Meetings

The following is a list of the meetings held during the 12 months ending 31st March, 1955:

General Meetings		
Ordinary Meetings ..	12	
Joint Meeting	1	
Annual General Meeting	1	
Annual General Meeting (Incorporated Benevolent Fund)	1	
Extra Meetings ..	3	
Measurements Section ..	14	
Radio Section	17	
Supply Section	10	
Utilization Section ..	8	
Informal Meetings ..	7	
Education Discussion Circle	8	
Special Lecture	1	
District Meetings ..	27	
*Local Centres		
East Midland ..	22	(5)
Cambridge Radio Group	6	(4)
Mersey and North Wales	20	(8)
North-Eastern ..	19	(8)
Radio and Measurements Group ..	12	(4)
North Midland ..	19	(7)
Utilization Group	6	(7)
North-Western ..	8	(7)
Measurements Group	5	(5)
Radio Group ..	5	(5)
Supply Group ..	6	(7)
Utilization Group	5	(6)
Northern Ireland ..	8	(6)
Scottish	6	(7)
South Midland ..	14	(8)
Radio Group ..	6	(6)
Supply and Utilization Group ..	6	(5)
Southern	22	(8)
	305	(113)

Council and Committee Meetings	
Council Meetings	12
London Committees	
Associations for Technicians	2
Courses for Technicians ..	1
Education and Training (and Sub-Committees and Panels)	18
Electrical Exhibitions ..	2
Examinations (and Sub-Committees and Panels)	24
Finance	8
General Purposes (and Sub-Committees and Panels)	19
Hon. Secretaries' Conference: Local Centres and Sub-Centres	1
Students' Sections ..	1
Incorporated Benevolent Fund (and Sub-Committees)	16
Informal Meetings	2
Joint Advisory Committee on Education	2
Joint Committee on Model Forms of General Conditions of Contract (and Sub-Committees and Panels) ..	14
Joint Committee on Practical Training in the Electrical Engineering Industry (and Panels)	2
Joint Consultative Committee	1
Joint Part I Examination ..	6
Local Centres	2
Measurements Section (and Sub-Committees and Panels)	34
Membership (and Panels) ..	12
	179

General Meetings	305	(113)
Local Centres (contd.)		
Western	11	(7)
Supply Group ..	5	(3)
Utilization Group	6	(2)
*Local Sub-Centres		
North Lancashire ..	11	(8)
North Scotland ..	15	(10)
North Staffordshire ..	9	(8)
Rugby	11	(6)
Sheffield	8	(3)
South-East Scotland	13	(6)
South-West Scotland	10	(8)
South-Western ..	8	(7)
Tees-Side	7	(7)
West Wales (Swansea)	10	(8)
*Students' Sections		
Bristol	11	(5)
Cardiff	8	(5)
East Midland ..	11	(10)
London	21	(11)
Mersey and North Wales	11	(8)
North-Eastern ..	13	(8)
North Midland ..	11	(8)
North Scotland ..	11	(3)
North Staffordshire ..	9	(8)
North-Western ..	8	(9)
Northern Ireland ..	6	(6)
Rugby	9	(8)
Sheffield	10	(6)
Southern	10	(9)
South-East Scotland	7	(5)
South Midland ..	13	(8)
South-West Scotland	7	(5)
	605	(318)

Council and Committee Meetings	179
Model Forms of General Conditions of Contract (Electrical) (and Panels) ..	2
National Certificates:	
England and Wales (and Sub-Committees) ..	2
Northern Ireland	1
Scotland	1
Oversea Activities	2
Papers (and Sub-Committees and Panels)	19
Radio Equipment for Civil Aircraft	1
Radio Interference	2
Radio Section (and Sub-Committees and Panels) ..	60
Regulations for the Electrical Equipment of Ships (and Sub-Committees)	2
Research	1
Scholarships (and Panels) ..	3
Science Abstracts	3
Supply Section (and Sub-Committees)	12
Utilization Section (and Sub-Committees)	23
Wiring Regulations (and Sub-Committees and Panels) ..	45
Other London Committees ..	5
Centres, Sub-Centres and Students' Section Committees (see details in parentheses in left-hand column)	318
	681

Also Code Drafting Committees convened for the Council for Codes of Practice	6
General Meetings	605
Council and Committees	681
Codes of Practice	6
Grand Total	1292

* The number of Committee meetings held are shown in each case in parentheses, and the total number of these Committee meetings is entered at the foot of the right-hand column.

Income and Expenditure Account for the Year ended 31st December, 1954

Dr. EXPENDITURE

Year ended 31 Dec., 1953		£	£	£
£	To Management:—			
	Salaries, Wages and National Insurance	62,997		
	Staff Provident Scheme	5,166		
	Staff Canteen Subsidies	530		
	Printing, Stationery and Office Requisites	7,014		
	Postage of Correspondence and Notices	3,102		
	Telephone	1,032		
	Travelling Expenses	2,649		
			82,490	
	Less Charged to "Science Abstracts"		2,838	
74,992				79,652
	„ Institution Building:—			
	Ground Rent		2,201	
	Rates		5,455	
	Heating		2,742	
	Lighting and Power		1,231	
	Insurance		487	
	Household Requisites and Cleaning		3,036	
	Transferred to Repairs Suspense Account		6,000	
			21,152	
	Less Rents from Tenants	7,319		
	Charged to "Science Abstracts"	500		
			7,819	
13,650				13,333
1,586	„ Furniture and Fittings (Repairs and Renewals)			2,168
	„ Journal and Proceedings:—			
	Printing		25,842	
	Paper		11,381	
	Postage		6,020	
	Wrappers and Envelopes		624	
			43,867	
	Less Subscriptions	9,178		
	Sales and Advertisements	21,020		
			30,198	
15,692				13,669
—	Journal Ten Year Index			595
1,933	„ Students' Quarterly Journal (Editing, Printing, Postage, etc.: *less* Sales)			2,138
462	„ Lending Library (Books, Printing, Postage, etc.)			378
	„ "Science Abstracts":—			
	Block Contribution		2,614	
	Per Capita		1,454	
4,204				4,068
£112,519	Carried Forward			£116,001

INCOME Cr.

Year ended 31 Dec., 1953		£	£
£			
129,481	By Subscriptions		132,982
5,578	„ Entrance Fees		5,136
126	„ Life Compositions		336
6,423	„ Interest on Investments		7,481
464	„ Deposit Interest		387
2,110	„ Members' Subscriptions to "Science Abstracts"		1,871
1,831	„ Sales of "Model General Conditions," "Wiring Regulations," "Ship Wiring Regulations" and "History of The Institution"		3,028
	„ Examinations:—		
	Institution Examination (Candidates' Fees and Sale of Papers)	12,852	
	Less Examiners' Fees, Printing, etc. (but excluding cost of Administration and Overhead Expenses, approx. £7,917)	5,781	
			7,071
	National Certificates and Diplomas (Candidates' and School Authorities' Fees)	10,159	
	Less Assessors' Fees, Stationery, Postage, Travelling Expenses, etc. (but excluding cost of Administration and Overhead Expenses, approx. £4,455)	5,824	
			4,335
11,036			11,406
1,683	„ Sales of Convention Proceedings		946
£158,732	Carried Forward		£163,573

Income and Expenditure Account—*continued*

Income and Expenditure Account—*continued*

Dr. EXPENDITURE—*continued*				Cr. INCOME—*continued*	
£		£	£	£	£
112,519	Brought Forward		116,001	*158,732* Brought Forward	163,573
	To Institution Meetings:—				
	Advance Proofs	1,216			
	Reporting	523			
	London Students' Section	410			
	Kelvin and Section Lectures	132			
	Refreshments, Assistance, etc.	973			
	Travelling Expenses of Authors of Papers	178			
	District Meetings	184			
3,130			3,616		
	„ Conventions:—				
705	Symposium on Insulating Materials	—			
—	Thermionic Valve Jubilee	193			
			193		
	„ Local Centres:—				
	Administration and Meetings Expenses	11,691			
	Travelling Expenses	288			
	Students' Lectures	206			
11,912			12,185		
	„ Oversea Branches:—				
	Administration Expenses	1,632			
	Loss on Exchange on remittances to London	492			
2,388			2,124		
1,706	„ Faraday and Children's Lectures		1,344		
403	„ Premiums for Papers, etc.		460		
1,122	„ Scholarships, provided from Institution Funds		1,458		
	„ Grants:—				
	Electrical Research Association	500			
	British Standards Institution	250			
	C.I.G.R.É.	75			
	Others	110			
933			935		
232	„ Annual Dinner		244		
285	„ Audit Fee		360		
24	„ British Electrical Power Convention		31		
658	„ Coronation Expenses		—		
250	„ Legal Expenses		15		
2,597	„ Miscellaneous Expenses		2,512		
159	„ Conference of Engineering Societies of Western Europe and U.S.A.		438		
—	„ Conference of Engineering Societies of the Commonwealth in London		962		
6,423	„ Transfer to Rebuilding Reserve Fund		7,481		
10,000	„ Transfer to General Reserve Fund		10,000		
278	„ Transfer to Sinking Fund (Premiums for Redemption of Cost of Building and Lease)		278		
	„ Depreciation:—				
	Library	511			
	Furniture, Fittings and Apparatus	970			
1,432			1,481		
157,156			162,118		
1,576	„ Balance Carried to Balance Sheet		1,455		
£158,732			£163,573	*£158,732*	£163,573

Balance Sheet, 31st December, 1954

	£	£
CREDITORS		39,390
SUBSCRIPTIONS, ETC., RECEIVED IN ADVANCE		12,367
REBUILDING RESERVE FUND:—		
Balance at 1st January, 1954	195,330	
Add Transfer from Income and Expenditure Account	7,481	
Gain on Sale of Securities	2,926	
		205,737
GENERAL RESERVE FUND:—		
Balance at 1st January, 1954	10,000	
Transfer from Income and Expenditure Account	10,000	
		20,000
RESERVE FUND FOR DEPRECIATION OF INSTITUTION BUILDING AND LEASE, BEING SURRENDER VALUE OF SINKING FUND POLICIES		23,501
REPAIRS SUSPENSE ACCOUNT:—		
Balance at 1st January, 1954	4,865	
Amount reserved in 1954	6,000	
	10,865	
Less Expenditure on Repairs in 1954	6,726	
		4,139
Surplus of Assets over Liabilities:—		
Balance at 1st January, 1954	76,858	
Add Excess of Income over Expenditure for 1954 brought forward from Income and Expenditure Account	1,455	
		78,313
		£383,447

H. W. GRIMMITT
Honorary Treasurer.

W. K. BRASHER
Secretary.

	£	£
INSTITUTION BUILDING AND LEASE (at cost)		69,631
SINKING FUND (Surrender Values of Policies for Redemption of Cost of Building and Lease)		23,501
LIBRARY (exclusive of the Ronalds Library and Faraday Papers, which are held in trust, but inclusive of Thompson Library):—		
As per last Balance Sheet	5,203	
Additions in 1954	909	
	6,112	
Less Depreciation at 10% (excluding Thompson Library)	511	
		5,601
FURNITURE, FITTINGS AND APPARATUS:—		
As per last Balance Sheet	18,338	
Additions in 1954	1,067	
	19,405	
Less Depreciation	970	
		18,435
DEBTORS		8,293
INSURANCE PREMIUMS AND SUNDRY PAYMENTS IN ADVANCE		2,557
STOCKS OF STATIONERY AND PAPER		9,780
REBUILDING FUND:—		
INVESTMENTS (at cost):—		
British Government Securities	134,685	
British Municipal Securities	24,136	
Dominion and Colonial Government Securities	27,781	
Public Boards and Trade Facilities Stocks	5,045	
Debenture Stocks	14,090	
(*Market value 31st December, 1954*, £205,555)		205,737
GENERAL RESERVE FUND:—		
INVESTMENTS (at cost):—		
British Government Securities	5,156	
Dominion Government Securities	9,914	
(*Market value 31st December, 1954*, £15,473)	15,070	
Cash—Uninvested	4,930	
		20,000
CASH IN HANDS OF LOCAL CENTRES ON 31ST DECEMBER, 1954		1,861
„ „ „ „ OVERSEA BRANCHES ON 31ST DECEMBER, 1954		1,743
CASH:—		
AT BANK	15,947	
IN HANDS OF SECRETARY	361	
		16,308
		£383,447

Report of the Auditors to the Members of The Institution of Electrical Engineers

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit. In our opinion proper books of account have been kept by The Institution so far as appears from our examination of those books. We have examined the above Balance Sheet and annexed Income and Expenditure account which are in agreement with the books of account. In our opinion and to the best of our information and according to the explanations given us the said accounts are properly drawn up and the Balance Sheet gives a true and fair view of the state of the Institution's affairs as at 31st December, 1954, and the Income and Expenditure account gives a true and fair view of the excess of Income over Expenditure for the year ended on that date.

ALLEN, ATTFIELD AND CO.,
Chartered Accountants,
24 MARTIN LANE, CANNON STREET, E.C.4.

21*st March*, 1955.

BLUMLEIN-BROWNE-WILLANS PREMIUM FUND

	£ s. d.		£ s. d.
Capital Account	700 0 0	Investment (at cost):—	
		£686 10s. 0d. British Electricity 4½% Stock 1974–79	700 0 0
	£700 0 0		£700 0 0

Dr. INCOME ACCOUNT Cr.

	£ s. d.		£ s. d.
To Balance carried to Balance Sheet	29 3 6	By Interest received	29 3 6
	£29 3 6		£29 3 6

WILLIAM BEEDIE ESSON SCHOLARSHIP TRUST FUND

	£ s. d.		£ s. d.
Capital Account	2,808 12 6	Investments (at cost):—	
		£1,755 15s. 6d. 3½% War Stock	1,853 2 6
		£200 New Zealand 3¼% Stock (1963–66)	200 0 0
		£100 East Africa High Commission 3½% Stock (1966–68) ..	97 10 0
		£400 British Electricity 3½% Stock (1976–79)	396 0 0
		£250 Birmingham Corporation 2½% Stock (1966–71) ..	250 0 0
		Cash	12 0 0
	£2,808 12 6		£2,808 12 6

Dr. INCOME ACCOUNT Cr.

	£ s. d.		£ s. d.
To Amount paid to Scholars	90 0 0	By Balance (as per last Account)	145 13 11
„ Balance carried to Balance Sheet	147 7 11	„ Interest received	91 14 0
	£237 7 11		£237 7 11

DAVID HUGHES SCHOLARSHIP TRUST FUND

	£ s. d.		£ s. d.
Capital Account	2,000 0 0	Investment (at cost):—	
		£2,045 Metropolitan Water Board (Staines Reservoirs) 3% Guaranteed Debenture Stock (1922 or after)	1,998 15 0
		Cash	1 5 0
	£2,000 0 0		£2,000 0 0

Dr. INCOME ACCOUNT Cr.

	£ s. d.		£ s. d.
To Balance (as per last Account)	9 12 0	By Interest received	61 7 0
„ Amount paid to Scholar	30 0 0		
„ Balance carried to Balance Sheet	21 15 0		
	£61 7 0		£61 7 0

I.M.E.A. SCHOLARSHIP FUND

	£ s. d.		£ s. d.
Capital Account	15,202 0 11	Investments (at cost):—	
		£5,965 5s. 10d. 3½% War Stock	5,965 5 10
		£4,500 3% Savings Bonds (1960–70)	4,500 0 0
		£1,867 0s. 9d. British Electricity 3% Stock (1974–77)	1,736 15 1
		£1,000 Bristol Corporation 3½% Stock (1961–66)	1,000 0 0
		£1,000 Coventry Corporation 3½% Stock (1960–64)	1,000 0 0
		£1,000 Paisley Corporation 3½% Stock (1958–60)	1,000 0 0
	£15,202 0 11		£15,202 0 11

INCOME ACCOUNT

Dr.	£ s. d.		Cr. £ s. d.
To Amount paid to Scholars	525 0 0	By Balance (as per last Account)	527 19 0
„ Balance carried to Balance Sheet	507 14 10	„ Interest received	504 15 10
	£1,032 14 10		£1,032 14 10

JOHN DOUGLAS KNIGHT AND ELIZABETH DUNCAN KNIGHT FUND

	£ s. d.		£ s. d
Capital Account	980 2 9	Investments (transferred):—	
		£333 6s. 8d. 3% Savings Bonds (1960–70)	333 6 8
		£624 9s. 6d. 3½% Conversion Stock	624 9 6
		Cash	22 6 7
	£980 2 9		£980 2 9

INCOME ACCOUNT

Dr.	£ s. d.		Cr. £ s. d.
To Amount paid to Scholars	70 0 0	By Balance (as per last Account)	63 14 0
„ Balance carried to Balance Sheet	25 11 0	„ Interest received	31 17 0
	£95 11 0		£95 11 0

SIR EDWARD MANVILLE SCHOLARSHIP FUND

	£ s. d.		£ s. d.
Capital Account	5,000 0 0	Investment (at cost):—	
		£5,000 3% Savings Bonds (1955–65)	5,000 0 0
	£5,000 0 0		£5,000 0 0

INCOME ACCOUNT

Dr.	£ s. d.		Cr. £ s. d.
To Amount paid to Scholars	187 10 0	By Balance (as per last Account)	129 15 8
„ Balance carried to Balance Sheet	92 5 8	„ Interest received	150 0 0
	£279 15 8		£279 15 8

PAGE PRIZE FUND

	£ s. d.		£ s. d.
Capital Account	100 19 5	Investments (at cost):—	
		£50 3½% War Stock	50 19 5
		£56 4s. 5d. British Electricity 3% Guaranteed Stock (1968–73)	50 0 0
	£100 19 5		£100 19 5

INCOME ACCOUNT

Dr.	£ s. d.		Cr. £ s. d.
To Awards of Prizes	10 10 0	By Balance (as per last Account)	13 6 11
„ Balance carried to Balance Sheet	6 5 7	„ Interest received	3 8 8
	£16 15 7		£16 15 7

SIR CHARLES A. PARSONS MEMORIAL SCHOLARSHIP

INCOME ACCOUNT

Dr.	£ s. d.		Cr. £ s. d.
To Amount paid to Scholar	45 0 0	By Balance brought forward	40 14 6
„ Balance as per Bank Account	47 2 0	„ Interest received	51 7 6
	£92 2 0		£92 2 0

Note.—The Capital of this Fund is invested by the Charity Commission.

PAUL SCHOLARSHIP FUND

	£ s. d.		£ s. d.
Capital Account	1,000 0 0	Investments (at cost):—	
Add Legacy from Estate of the late Mrs. Ellen Paul	3,000 0 0	£3,019 3s. 7d. 3½% Funding Stock (1999–2004)	3,000 0 0
	4,000 0 0	£625 4% Funding Stock (1960–90)	500 0 0
		£562 4s. 7d. British Electricity 3% Guaranteed Stock (1968–73)	500 0 0
	£4,000 0 0		£4,000 0 0

INCOME ACCOUNT

Dr.	£ s. d.		Cr. £ s. d.
To Balance carried to Balance Sheet	48 14 9	By Balance (as per last Account)	6 17 5
		„ Interest received	41 17 4
	£48 14 9		£48 14 9

SALOMONS SCHOLARSHIP TRUST FUND

	£ s. d.		£ s. d.
Capital Account	2,044 15 4	Investment (at cost):— £2,485 10s. 7d. Commonwealth of Australia 3% Stock (1972–74)	2,044 15 4
	£2,044 15 4		£2,044 15 4

INCOME ACCOUNT

Dr.	£ s. d.		Cr. £ s. d.
To Amount paid to Scholar	45 0 0	By Balance (as per last Account)	31 2 4
„ Balance carried to Balance Sheet	60 13 8	„ Interest received	74 11 4
	£105 13 8		£105 13 8

SWAN MEMORIAL SCHOLARSHIP FUND

	£ s. d.		£ s. d.
Capital Account	3,312 15 10	Investments (at cost):—	
		£905 10s. 4d. 3% Savings Bonds (1960–70)	995 0 6
		£1,200 British Electricity 3½% Stock (1976–79)	1,194 4 0
		£1,135 17s. 9d. 3½% Conversion Stock (1961 or after)	1,123 11 4
	£3,312 15 10		£3,312 15 10

INCOME ACCOUNT

Dr.	£ s. d.		Cr. £ s. d.
To Balance carried to Balance Sheet	260 1 7	By Balance (as per last Account)	151 3 1
		„ Interest received	108 18 6
	£260 1 7		£260 1 7

THORROWGOOD SCHOLARSHIP TRUST FUND

	£ s. d.		£ s. d.
Capital Account	1,000 0 0	Investment (at cost):— £1,005 Agricultural Mortgage Corporation 5% Debenture Stock (1959–89)	1,000 0 0
	£1,000 0 0		£1,000 0 0

INCOME ACCOUNT

Dr.	£ s. d.		Cr. £ s. d.
To Amount paid to Scholars	25 0 0	By Balance (as per last Account	65 19 11
„ Balance carried to Balance Sheet	91 4 11	„ Interest received	50 5 0
	£116 4 11		£116 4 11

WAR THANKSGIVING EDUCATION AND RESEARCH FUND (No. 1)

	£ s. d.		£ s. d.
Capital Account	1,700 0 0	Investment (at cost):— £2,000 3½% War Stock	1,700 0 0
	£1,700 0 0		£1,700 0 0

INCOME ACCOUNT

Dr.	£ s. d.		Cr. £ s. d.
To Amount paid to Scholar	200 0 0	By Balance (as per last Account)	266 5 0
„ Balance carried to Balance Sheet	136 5 0	„ Interest received	70 0 0
	£336 5 0		£336 5 0

WILDE BENEVOLENT TRUST FUND

	£ s. d.		£ s. d.
Capital Account	3,048 10 2	Investments (at cost):—	
		£1,397 18s. 6d. British Transport 3% Guaranteed Stock (1978–88)	1,744 3 11
		£100 London County 2¾% Consolidated Stock (1960–70)	101 8 6
		£250 Commonwealth of Australia 3% Stock (1972–74)	250 0 0
		£500 3½% War Stock	501 9 3
		£381 15s. 1d. 4% Funding Stock (1960–90)	300 0 0
		£200 3½% Conversion Stock (1961 or after)	151 8 6
	£3,048 10 2		£3,048 10 2

INCOME ACCOUNT

Dr.	£ s. d.		Cr. £ s. d.
To Grants authorized	100 0 0	By Balance (as per last Account)	59 0 11
„ Balance—Deposit Account 48 9 10		„ Interest received	92 16 5
Tax Recoverable 3 7 6			
	51 17 4		
	£151 17 4		£151 17 4

RADIO AIDS TO MARINE NAVIGATION

An Informal Lecture to the Radio Section

On the 24th January, 1955, Captain F. J. Wylie, R.N., delivered an informal lecture with the above title at a meeting of the Radio Section. A summary of his remarks, and of the subsequent discussion, is printed below.

CAPT. F. J. WYLIE began by saying that the requirements of the mariner vary with his distance from land—or rather, from danger. In mid-ocean they might be non-existent, and amid the shoals of the southern North Sea emphatic. While a single radio aid obviously could not fulfil all needs, the seaman would hope that, in time, there might be a greater degree of international uniformity of practice than exists to-day.

In 1947 an international meeting on radio aids to marine navigation made recommendations regarding the accuracy of radio position-fixing systems and concluded that it was a function of these systems to afford safe entry into the zone in which radar becomes effective.

Ship-borne radar is unique among aids in that it demands no external co-operation other than the returning of an echo. Apparatus is being rapidly developed which has many advantages and a few shortcomings. There is displayed in modern radar systems quite a considerable variation in type and standard; as experience accumulates and the art of using radar develops, it may call for restrictions on these variations. So far as the use of radar is concerned, there are indications that better education is needed in connection with anti-collision tactics. Shore-based radar has not yet been given much opportunity for proving itself as a means of maintaining port operation in low visibility, and fog is still the master at most ports of the world.

To bring ships safely into the radar zone there are the directional and the hyperbolic systems. Ship direction-finding, the oldest of the radio aids, is still very much alive, owing in some part to the Convention on Safety of Life at Sea, which makes it a compulsory fitting in ships above 1 600 tons on international voyages. It is the only aid which can "home" onto the radio signal of a known vessel. For navigation, however, it offers rather a poor accuracy compared with the hyperbolic systems.

Shore direction-finding is employed less and less, although the system remains for distress purposes. However, the shore directional transmitter of the "course beacon" type seems to be coming into favour. The long-range directional aid, Consol, is not much used by the mariner.

Loran and Decca are the principal hyperbolic systems, the former for long-range and the latter for medium- and short-range working. Loran is little used by British ships, but the phenomenal accuracy of Decca has made it extremely popular in N.W. Europe.

From the British seaman the call is probably for expansion of the use of Decca, and for improvements in radar and the secondary aids and ancillaries which will increase its value as an aid to avoiding grounding and collision.

In the discussion which followed Capt. Wylie's lecture it was generally recognized that in a developing art the present variety of systems is to be expected, and although simplification (with the maintenance or improvement of high performance standards) is to be encouraged, no one system appears likely ever to provide all that was required.

The advantage of ship-borne radar systems in not requiring active co-operation from other ships or shore was also recognized, although the need for generous bandwidth was a drawback. Methods of plotting and the difficulty of tracing and interpreting a number of tracks also remain problems.

Attention was drawn to the distinct needs of the navigator in making a landfall, in navigating in narrow waters and in avoiding collision; the necessary characteristics, such as range and accuracy, of radar and other aids for these purposes were discussed, and the importance of definition, particularly for avoiding collision, was brought out. When two ships are in proximity it is essential for the navigator of one to determine the course of the other. The advantage, particularly in such a situation, of stabilizing a p.p.i. presentation by means of a gyro-compass was realized though the system was not yet used in many ships.

Most speakers concentrated upon the contribution which navigational aids make to safety, but attention was also drawn to the economic aspect of improved navigation.

The human factor was stressed, since the best equipment depends for its efficiency on the user, and training is thus important. A plea was made for closer liaison between equipment designers and users during development. Designers must respect the fact that the safety of the ship is the responsibility of the officer in charge, whatever advice he might receive to assist him. In practice, too, the navigator is helped by cross-checks between different devices, one of which might for example be an echo-sounder.

The needs of aircraft necessarily differ from those of shipping, so that the same navigational aids cannot always serve both. Where possible, however, it is desirable to provide a common service, and there is need to extend the coverage of navigational systems over wider areas of the world.

Numerous other topics were touched upon, ranging from "rules of the road" at sea to the avoidance of anchor-drag faults on submarine cables.

Journal I.E.E., July 1955

The measurement of IRON LOSSES IN SHEET STEELS

Prof. F. BRAILSFORD, Ph.D., Wh. Sc., *Member*

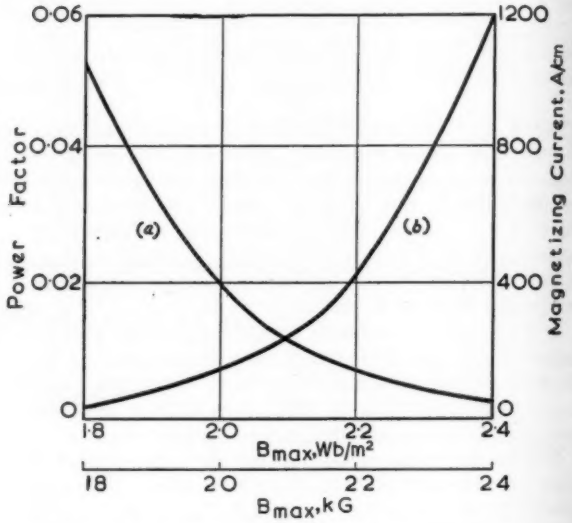
Professor F. Brailsford writes here about an important new method of measuring iron losses in sheet steels developed by himself and Dr. C. G. Bradshaw of University College, London, and described in their paper entitled "Iron Losses at High Magnetic Flux Densities in Electrical Sheet Steels." This was read before the Measurements Section on the 1st March, 1955, and an account of the meeting appeared in the May Journal on p. 309. The method is likely to be used mainly at high values of magnetic induction and it may be further developed for employment in industrial laboratories.

THE FIRST use of thin sheet material for magnetic purposes was probably in or about the year 1837. The discovery of electromagnetic induction by Faraday led some experimenters to build induction coils, and, with these, a person grasping the terminals of a secondary winding could be treated to electric shocks when the current in the primary circuit was interrupted. Sturgeon found that the "shocking power" of one of his coils was greatly improved when he substituted a rolled-up sheet of iron for the solid iron core. However, by 1870 at least, it was common to use insulated iron laminations in the armatures of generators and motors.

Heaviside (1884) and J. J. Thomson (1892), making the assumptions of sinusoidal magnetic flux and constant permeability, showed how to calculate the internal flux and eddy-current distribution, and the eddy-current power losses, in relation to the frequency and the lamination thickness. It was also soon realized that there was another component of iron loss, due to magnetic hysteresis, which usually was larger than that due to eddy currents.

The amplitude of the working flux density in a transformer core is limited by the position of the "knee point" of the magnetization curve of the core material, so that in hot-rolled silicon-iron transformer sheets the value of B_{max} will not usually exceed about 1·4 Wb/m² (14 kG). In generator and motor punchings, however, a limit to the tooth flux densities is imposed by the magnetic saturation characteristics of the iron, but these densities may exceed 2·0 Wb/m². Surprising though it may seem in view of the universal employment in rotating electrical machinery of flux densities reaching, say, 2·4 Wb/m², there have hitherto been no specific iron loss data for any materials for inductions greater than $B_{max} = 1{\cdot}8$ Wb/m².

Wattmeter methods of measuring iron losses begin to run into difficulty when, for a dynamo iron, the flux density reaches about $B_{max} = 1{\cdot}5$ Wb/m², although results have been obtained up to 1·8 Wb/m². Fig. 1 illustrates the very onerous conditions under which a wattmeter would operate for flux densities in the range



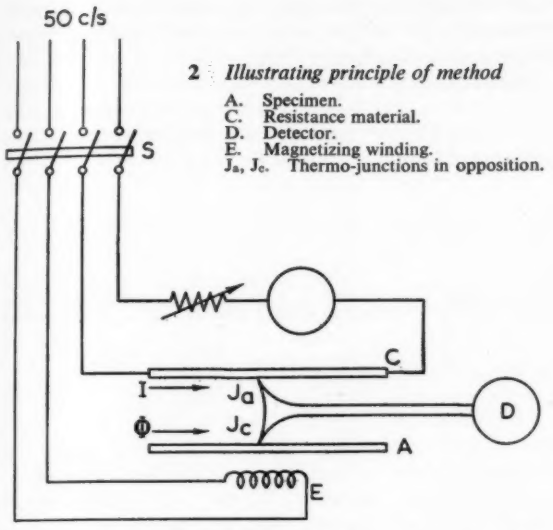
1 *The curves show the low lagging power-factors* (a) *and high magnetizing currents* (b) *occurring at high flux densities in dynamo iron for a frequency of 50 c/s*
Thickness of iron = 0·018 in.

1·8–2·4 Wb/m² in dynamo iron. Small phase-angle defects in the wattmeter and in its associated components and circuits, even at a frequency of 50 c/s, may now introduce serious errors because of the low lagging power factors. The rapidly-rising magnetizing current accentuates the problem, not only by the heat produced in the primary circuit, but also where a sinusoidal flux in the specimen is being aimed at, by the large harmonic components of current which are inherent.

The method of measurement described in the paper* avoids these difficulties, and measurements of iron loss have been made on a number of sheet materials at a frequency of 50 c/s, and over the complete range of flux densities from zero up to about $B_{max} = 2{\cdot}4$ Wb/m².

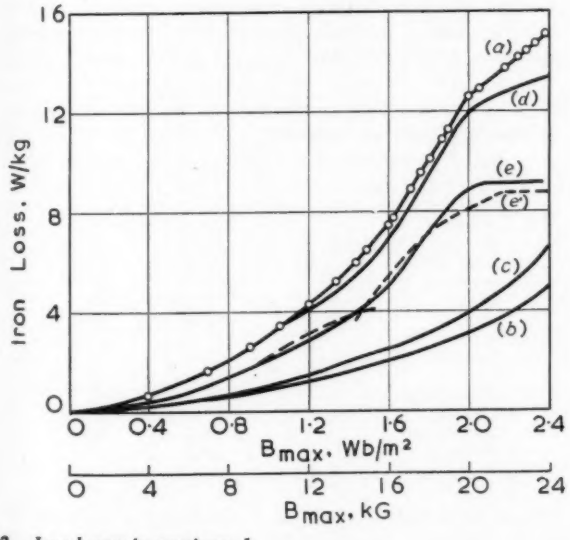
The scheme adopted is illustrated in principle in Fig. 2. The single test strip A, magnetized by the winding E, is heated by its iron losses when the switch S is closed. Simultaneously the non-ferromagnetic strip of resistance material C is independently heated by the current I. The initial rates-of-rise of temperature of the strips A and C are compared by means of the opposed thermo-junctions J_a and J_c connected to the detector D. If the current I has been pre-adjusted by trial so that on closing the switch there is no deflection of the detector, the ratio of the specific iron loss in the specimen to the

* "Iron Losses at High Magnetic Flux Densities in Electrical Sheet Steels," *Proceedings I.E.E.*, Paper No. 1794 M, February, 1955. To be republished in Vol. 102, Part A.



2 *Illustrating principle of method*
A. Specimen.
C. Resistance material.
D. Detector.
E. Magnetizing winding.
J_a, J_c. Thermo-junctions in opposition.

specific power in the resistance strip is equal to the ratio of the specific heats of the two materials. The switch S need be closed only for a few seconds at a time in order to observe the detector, and hence the magnetizing coil may be heavily overloaded intermittently in order to reach the high flux densities required without overheating. In the complete apparatus, the test strip in a closed magnetic circuit was sandwiched between strips of the resistance material. Under conditions of balance there was therefore no temperature gradient normal to the surfaces and so no loss or gain of heat from them.



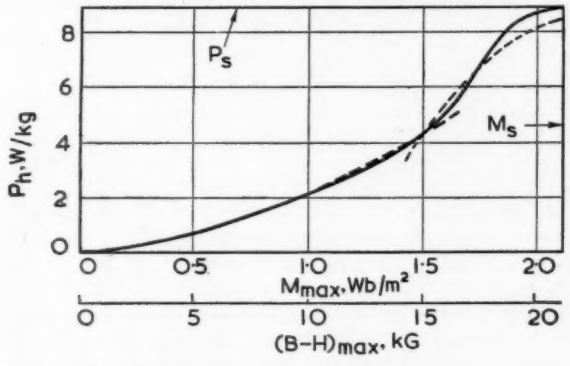
3 *Iron losses in specimen 1*
(*a*) Observed total iron loss.
(*b*) Calculated eddy-current loss for sinusoidal flux.
(*c*) Corrected eddy-current loss.
(*d*) Corrected total iron loss.
(*e*) Dynamic hysteresis loss.
(*e'*) Calculated empirical curves.

A very sensitive d.c. detector is required. For example, an iron loss of 1 W/kg produces a rise of temperature in the specimen of about 0·008° C in 4 sec, giving an e.m.f. in each junction at balance of about 0·3 μV. To detect a difference in the rates of rise of temperature of 0·5% in this example therefore requires a detector sensitivity of about 700 mm/μV, which gives an observable out-of-balance deflection of 1 mm. This degree of sensitivity was obtained by employing a galvanometer-amplifier system which is described in the paper.

The results shown in Fig. 3 for a specimen of 0·018 in dynamo iron at 50 c/s are typical of the results obtained for a number of silicon-iron sheet materials and for one sample of cobalt-iron. Curve (*a*) gives the experimentally-observed iron loss in relation to the induction B_{max}. Curve (*d*) is the result obtained when the observed values are corrected to sinusoidal flux conditions, while curve (*e*) is the dynamic hysteresis loss obtained by subtracting from the total iron loss the eddy-current component calculated from the classical formula. With several other thinner specimens having higher electrical resistivities the eddy-current component was relatively very much smaller, so that possible uncertainties in the calculation of the eddy-current component of loss or in correcting the observed iron loss to sinusoidal conditions were unimportant.

Perhaps the most interesting feature of the results, common to all the specimens investigated, is that the component of hysteresis loss reaches a fairly definite saturation value at high flux densities. The shape of the hysteresis-loss induction curve in fact reflects the shape of the magnetization curve of the material with a rounded discontinuity at a flux density corresponding to the "knee" of the magnetization curve, though this merely confirms a known result at the lower flux densities.

In Fig. 4 the hysteresis loss p_h is replotted in relation



4 *Complete hysteresis-loss characteristic*

to the intensity of magnetization M_{max}. Since now both p_h and M_{max} have saturation values p_s and M_s respectively, the curve in Fig. 4 represents the complete characteristic of the material.

In the paper the authors sought to find simple empirical

formulae for the hot-rolled materials which would fit characteristics of the form shown in Fig. 4, and which would, at the same time, enable the upper part of the curve to be predicted if only the lower part, which may readily be measured by standard routine methods, were known. The broken lines in Fig. 4 are drawn from such empirical formulae. This attempted method, however, which would have great practical usefulness if it could be shown to be well founded, was found satisfactory for only three materials out of six.

When the paper was read before The Institution it was followed by a very interesting and well-informed discussion, which, over-running the available time, had unfortunately to be curtailed by the Chairman.

MIXED THERMAL AND HYDRO-ELECTRIC GENERATION SYSTEMS

Some Considerations put forward in a recent Institution Paper

THERE can surely be few inhabited countries in the world to-day in which the demand for electricity has not increased tremendously in the last decade. This in turn has led to the construction of more and more generating stations and consequently to an increasing demand for fuels for the prime movers. The prospects of nuclear energy seem promising, but nuclear stations are still largely in the development stage, and the world still relies on its established sources—coal, oil and water.

The pros and cons of thermal and hydro-electric generation have long been argued, but the ultimate decision as to which source shall predominate in any given country is essentially conditioned by natural availability. In the United Kingdom, for example, the total amount of energy which could be generated by normal hydro-electric stations is a small proportion of the country's needs, so that the traditional coal-fired station predominates. Even so, our resources of coal are by no means inexhaustible, and our natural supplies have so been squandered that some experts forecast the end of useful supplies within the next 200 years.

In Switzerland, on the other hand, water power is cheap and plentiful; but the occasional very dry summer, or a winter so severe as to freeze the water, has shown that there is a limit to the reliability of hydro-electric generation imposed by Nature. None the less, where water power is available there is much in favour of its use, especially in combination with thermal generation. Table 1 shows the various proportions of thermal and hydro-electric generation in a number of important countries for which data are available. It is perhaps of interest to note that Scotland has been shown separately from the rest of Great Britain, because of the very marked difference between the two brought about by the sterling work of the North of Scotland Hydro-Electric Board.

However, as demands increase and hydro-electric sites become used up or thermal sources dwindle, the position must change, and the problems of planning and operating a mixed thermal–hydro-electric economy must be faced. True, the plants are to a considerable extent complementary, and a mixed system usually brings advantages: but the problem of getting the most out of the mixture is complex indeed. Some idea of just how complex is given in a paper recently published in the *Proceedings*,* which considers the effect of a mixed system on the design of the hydro-electric plant and shows how the optimum design may be determined theoretically. In practice, of course, only approximations to the optimum are likely, but there will probably be great advantages in obtaining the most accurate approximations with the data available.

Because the incremental cost of increasing the installed capacity in a hydro-electric station is nearly always less than the corresponding cost in a thermal station, it will generally be best to design the former for the maximum installed capacity (and therefore the lowest load-factor) which the system can accept. However, this poses the problem of what is the lowest acceptable load-factor for any given station. There is no exact method of answering this question, but Mr. Haldane and Mr. Blackstone suggest an empirical method in their paper, although it is still necessary to allow for factors peculiar to each particular installation—such as transmission limitations and lack of operating flexibility—which tend to increase

Table 1. Approximate proportions of thermal and hydro-electric plant in various countries†

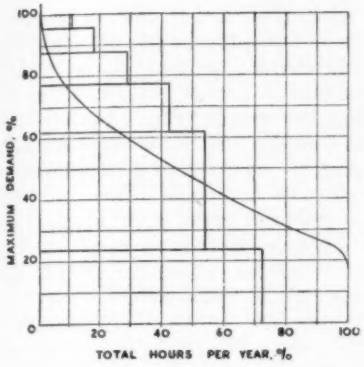
	Thermal %	Hydro-electric %
England and Wales	99·7	0·3
Australia	88·1	11·9
Western Germany	81·1	18·9
United States	77·8	22·2
Scotland	69·4	30·6
France	55·5	44·5
Finland	39·8	60·2
Japan	37·4	62·6
Sweden	22·7	77·3
Italy	18·3	81·7
New Zealand	11·5	88·5
Canada	9·6	90·4
Switzerland	6·6	93·4
Norway	4·2	95·8

Source: United Nations Bulletin of Statistics, November, 1953.

* HALDANE, T. G. N., and BLACKSTONE, P. L.: "Problems of Hydro-Electric Design in Mixed Thermal-Hydro-Electric Systems," *Proceedings I.E.E.*, Paper No. 1749 S, November, 1954 (102, A, p. 311).

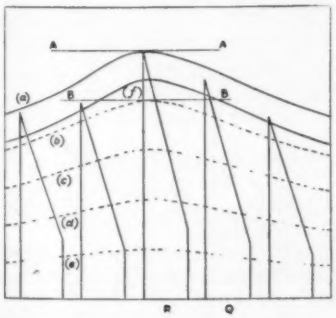
the acceptable load-factor. The empirical method suggested, however, does provide a more realistic starting point for assessing the lowest acceptable firm annual load-factor (or the maximum acceptable installed capacity) for any given block of kilowatt-hours.

The problem is illustrated by Fig. 1, which shows the



1 *Typical annual load/duration curve, showing energy generated by different blocks of plant*

system annual load/duration curve, superimposed with figures for the energy which may, in fact, be generated by the various blocks of thermal plant. The ideal condition, of course, would be if the energy generated by the different blocks of plant exactly fitted the load/duration curve, but because of practical difficulties it is inevitable that too much energy would be generated by the least efficient plant (towards the top of the curve) and, correspondingly, too little by the most efficient plant (towards the bottom of the curve). In order to ascertain a more practical optimum condition at which to aim (in contrast to the quite impracticable optimum represented by the annual load/duration curve) the empirical method illustrated by Fig. 2 is offered. Briefly, this implies that peak-load plant which carries the top $x\%$ of the load on the day of annual maximum demand should

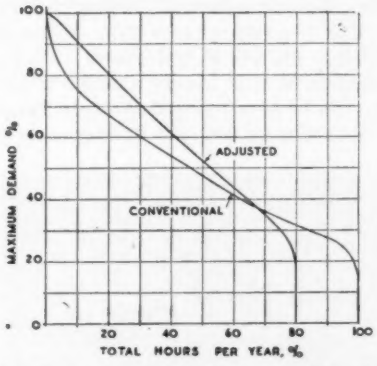


2 *Basis of adjusted load/duration curve*

(*a*) Maximum demand (m.d.).
(*b*) 80% m.d.
(*c*) 60% m.d.
(*d*) 40% m.d.
(*e*) 20% m.d.
(*f*) Minimum demand.

be capable of carrying the top $x\%$ on any other weekday when weather or other conditions lead to an extreme peak for the time of year.

The final effect of doing this is shown in Fig. 3, in



3 *Conventional and adjusted load/duration curves*

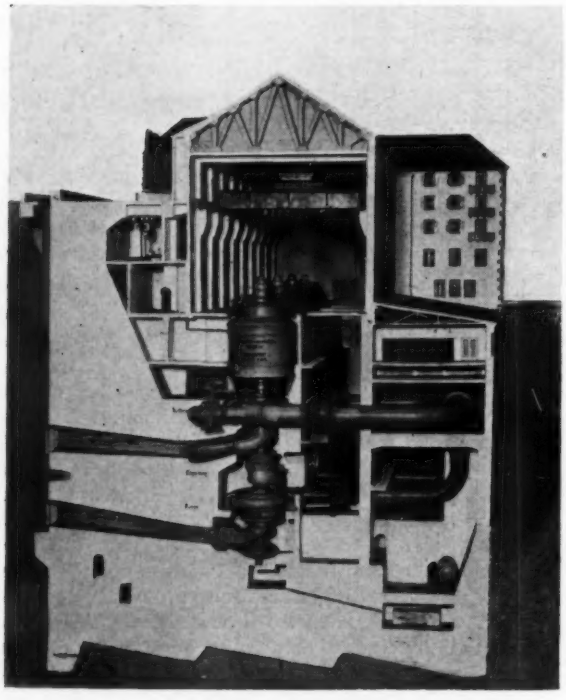
which the curve marked "conventional" is the ordinary annual load/duration curve and the curve marked "adjusted" is the curve arrived at by the method just described. A rough analogy would be to say that the conventional curve is similar to the Carnot-cycle efficiency of a heat engine, whereas the "adjusted" curve corresponds to the Rankin-cycle efficiency. The one is an unattainable ideal, the other attainable subject to such other limitations as may exist in each particular engine.

The introduction of hydro-electric plant at the top of the load/duration curve of a mixed system has four important effects on the total fuel consumption, the first three being favourable and the fourth unfavourable to the use of low-load-factor hydro-electric plant. The overall effect can be ascertained only by long-term studies of alternative systems, one with, and one without, peak-load hydro-electric plant. This cannot be done with any great accuracy, but typical studies made in the past confirm that it normally pays to install hydro-electric plant at the minimum acceptable load factor. However, whatever this may be at any given time, it may well change with circumstances, and so provision should where possible be made for increasing the installed capacity at a future date.

Use of Pumps

Another matter to consider is whether or not provision for pumping would be worth while. To a large extent a pump can be regarded as being equivalent to extra storage capacity, and there must, of course, be both a tail pond from which to pump and relatively cheap off-peak energy (usually thermal) available for pumping. Apart from the possibility of increasing the firm output from any particular hydro-electric project, and perhaps thereby permitting an increase in installed capacity, the addition of a pump permits regular pumped storage to be superimposed on a natural project. There are various

ways in which substantial benefit may accrue, the particular one to be given primary consideration depending on the circumstances—for instance, the average level of the reservoir will be increased, with benefit both in total energy output and dependable capacity. In general there can be no doubt that a pump gives a new degree of freedom and flexibility and tends to increase security. The reversible pump-turbine is ideally suited for this purpose, as it is also for the pure pumped-storage scheme. The latter can be regarded as the final development of pumping to the situation where there is no natural run-off and the station depends entirely on pumping. Pumped storage has not hitherto received the general attention in Britain that it has in some European countries. Fig. 4 shows a model of the Witznau pumped-storage station in south-west Germany. The layout is quite conventional, with the pumps directly below the turbines; there are four 60 MW generators and the input to each pump is 35 000 b.h.p., the head being 870 ft.



4 *Model of the Witznau pumped-storage station*

However, it is interesting to note that pumped-storage schemes are now going ahead in the United States and Canada; a notable example is the new Sir Adam Beck station on the Niagara River downstream of the Falls, although the circumstances here are somewhat unusual. It is to be hoped that it will not be long before practical experience of pumped storage is obtained in the United Kingdom.

Nuclear Power

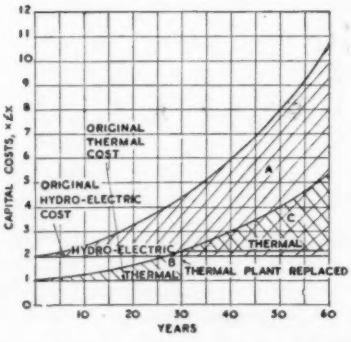
What is the probable effect of nuclear power stations on future hydro-electric projects? When the paper was written it was impossible to assess the cost of nuclear generation in 10 or 20 years' time. Since then a Government White Paper has added considerably to previous knowledge. The cost of nuclear energy remains much a matter of guess-work, though it is now estimated at 0·6d. per kWh after allowing for the sale of plutonium. It has however been decided to press ahead with a considerable programme of nuclear stations scheduled for completion during the next 10 years. Despite these changes the authors consider that this is no justification for postponing present hydro-electric development. Indeed it would be very imprudent to do so. The nuclear station programme might take longer than anticipated, and in any event there is the ever-increasing need in this and other countries to husband limited coal resources. Both nuclear and hydro-electric stations are required for this purpose and will be complementary.

The probable characteristics of future nuclear stations suggest that in certain respects they will be similar to hydro-electric stations. For instance, they are likely to be placed in remote districts and so will require comparatively long-distance transmission; they are also likely to involve relatively high capital costs and relatively low running costs.

However, both for technical and commercial reasons, a nuclear station will almost certainly operate at a very high load-factor and will not be suitable for peak-load operation, unlike a hydro-electric station. Consequently, there may be considerable advantage in the combination of base-load nuclear stations and peak-load hydro-electric stations, for the latter have a flexibility which is not likely to be possible with nuclear stations.

Price Levels

During the past 50 years there has been a fourfold increase in prices and a corresponding drop in the value of money. This has played a great part in the economics of hydro-electric generation, and since the monetary trend is expected by many people to continue indefinitely, if not at the same average rate, it is pertinent to consider

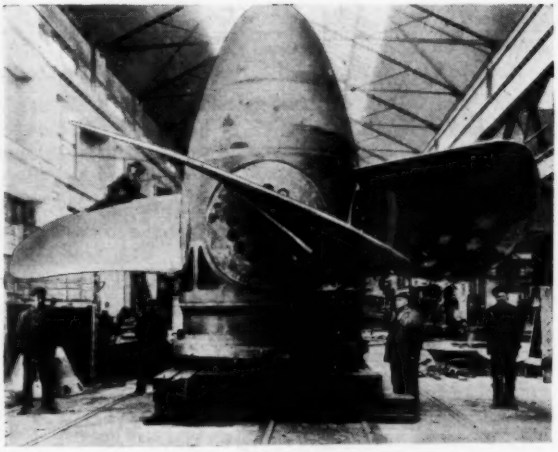


5 *Comparison of relative price levels and replacement costs*

its effect on both thermal and hydro-electric stations. Fig. 5 illustrates some of the aspects to be considered, although it is essentially only illustrative and ignores a number of secondary effects.

The curves are drawn on the assumption that prices continue to rise at the average rate of the past 50 years. It is also assumed that for a given installed capacity the capital cost of a thermal station is half that of a hydro-electric station and that the latter has a life of at least twice that of the thermal station. This is probably an understatement, since the civil engineering works which represent the major cost of a hydro-electric station have an almost indefinite life. But the main assumption is that benefit accrues to the owner of a station in proportion to the difference between the original cost of that station and the cost of building a similar station at any later date, although this is only approximately correct. The conclusion drawn is that the hydro-electric station gains very substantially, owing to its long life, although the gain is augmented by the fact that the initial investment is greater than that of the thermal station. The combined effect of these two factors is quite striking, since the comparison is between the large area A for the hydro-electric station and much smaller areas B and C for the thermal station.

Consideration of what has actually happened with hydro-electric stations built a few decades ago confirms the conclusions drawn. There are several stations which are to-day extremely profitable to the owners because of their relatively low original capital costs. However,



6 *The Kaplan runner for the station at Vargön, Sweden*

since the benefit is due to rising prices, it has accrued at the expense of other sections of the community.

Plant Development

The design of hydro-electric plant is now of a quality that leaves little scope for further improvement relative to that of other large generating plant. Development is now principally concentrated on obtaining higher efficiencies at higher speeds and outputs, since, subject to certain limitations, increases in either speed or output tend to lower the initial cost per kilowatt of installed capacity. Striking advances have been made in recent years in the design of Kaplan and Francis turbines for higher heads, thus permitting a higher specific speed for a given head and output. Fig. 6 shows the largest Kaplan-turbine runner yet built; 26 ft in diameter, it

7 *The Francis runner for the station at Castro, Spain*

develops 15 000 b.h.p. at a head of 14 ft, and is installed in the run-of-river station at Vargön, in Sweden. By contrast, the Francis runner shown in Fig. 7 is only 11 ft 3 in in diameter, yet because it can revolve so much faster, with a working head of 120 ft, it develops 59 000 b.h.p.; installed at Castro, in Spain, it is one of the largest Francis runners yet fabricated.

The striving for higher specific speed has led to increases in the upper limits at which a particular type of runner is used; not long ago it was considered abnormal to install Kaplan turbines for heads exceeding 100 ft and Francis turbines for heads exceeding 1 000 ft, yet, as Table 2 on page 452 shows, these limits have now been passed by considerable margins. On the other hand, greater specific speeds usually mean lower maximum efficiency and deeper excavation for the draft tube—especially for Kaplan machines; so there are many factors to be considered.

In terms of maximum power output the water turbo-generator had until recently a lead over its thermal counterpart, but with the decision to build thermal plants of 200 and 350 MW in Britain and the United States

respectively, it seems that hydro-electric plant must now take second place in this respect. At the moment the largest capacity is 138 MW, which British manufacturers have in hand for the Bersimis station of the Quebec Hydro-Electric Commission. While transport to site of both very large turbines and generators presents problems, it seems that the generator designer is well able to meet everything that the turbine designer requires of him. Further increases in capacity are more a matter of economics than of technology.

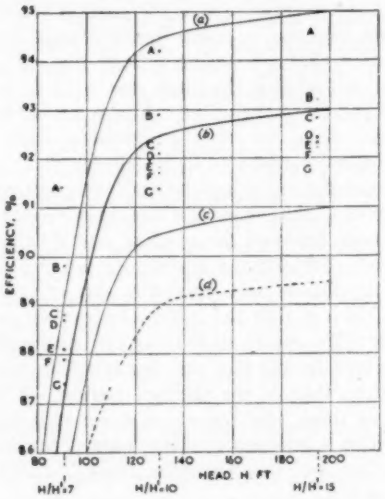
Table 2. Some existing high-head turbines

Station	Country	Head	Output	Speed
		ft	b.h.p.	r.p.m.
Kaplan Turbines				
Bort-Rhue	France	230	31 500	375
Barcis	Italy	199	13 500	500
Requejada	Spain	188	5 700	500
Invergarry*	Scotland	177	28 000	250
Pollaphuca	Ireland	165	25 000	300
Ligga	Sweden	130	105 500	125
Lavey	Switzerland	125	30 000	214
Francis Turbines				
Fionnay	Switzerland	1 490	63 000	750
Limberg	Austria	1 430	77 500	500
Vinstra	Norway	1 360	69 000	500
Fiastrome	Italy	1 320	20 000	1 000
Lages	Brazil	1 100	54 000	600
Lardit	France	1 100	30 000	750
Pelton Turbines				
Reisseck	Austria	5 800	31 000	750
Dixence	Switzerland	5 700	50 000	500
Mieville	Switzerland	4 750	47 500	500
Pragnieres	France	3 920	100 000	428

* Under construction.

The striving for fractional increases of efficiency is hampered by the inability of the hydraulic engineer to measure accurately on large machines the efficiency he has actually obtained, because of the difficulty of measuring accurately large flows of water. Site efficiency tests are expensive and their value is clearly less if the error of measurement is such as to justify a manufacturer asking for a $\pm 2\%$ tolerance on his guarantees. Hydraulic engineers are very conscious of this, and much thought is now being given in various countries to improvement in the hitherto accepted methods of flow measurement, and research has been carried out with new methods. Unfortunately, there is at present no commonly accepted method, and that used rather depends on the type of installation. Data on comparative tests taken on the same machine are scarce, and with that in mind some comparative and simultaneous tests with five or six different methods of flow measurement are being planned for one of the North of Scotland Hydro-Electric Board's machines under the auspices of the British Standards Committee for the testing of water turbines.

Because of this insufficiency there has been an increasing use of reduced-scale models tested under laboratory conditions; but there is some doubt about the most satisfactory formula for relating model and prototype efficiencies and, in particular, how it should be applied at outputs above and below that at which best efficiency occurs. Fig. 8 shows the results of a comprehensive set of model tests on a Francis turbine over a wide range of head. The curve of model efficiencies relates only to optimum efficiency at each head. Shown on it are the limits of $\pm 2\%$ tolerance for site testing and also, for three ratios of prototype to model head, the results obtained in stepping up the model efficiencies using seven of the formulae which have been derived by various authorities. If point A, which is exceptionally high, is disregarded it does seem that, at any rate in this particular turbine, the limits of error in assessing the prototype efficiency from model results may be rather less than the possible error in site testing. The fact that these formulae have no exact theoretical basis and are derived mainly from experiment on full-scale machines and homologous models is a further argument for pursuing the research into accurate measurement of large flows of water.



8 *Model tests and prototype efficiencies derived from different scale-effect formulae*

Model scale ratio = 5·23; model test head = 13 ft.
(*a*) Upper tolerance limit for site tests.
(*b*) Guaranteed.
(*c*) Lower tolerance limit for site tests.
(*d*) Model test results.

Reference has earlier been made to the economic advantages of the reversible pump-turbine. This type of machine is not new, but only within the last few years has its possible value come to be appreciated. Unless the electrical machine is designed for dual speed, the chosen speed must be a compromise between the best for a pump and the best for a turbine. In efficiency the machine will probably lose about 1% when generating and 1–2% when pumping as compared with a pure

turbine and pump, but it is possible to swing the figures in favour of either the pump or the turbine as desired. For instance, in a multi-unit peak-load station where one unit has been designed as a reversible machine, it may be desirable to have the highest possible efficiency as a pump with additional sacrifice as a turbine, because the hours of pumping may be appreciably more than those of generating. In such a station it should be possible to use the reversible machine only for extreme peak loads and so minimize the effect of reduced efficiency. The hydraulic machine will cost something of the order of 30% more than an ordinary turbine and its setting relative to tail water will have to be lower. The electrical machine will cost approximately the same, for the same rating, as a normal generator.

Conclusion

In conclusion it is wise to stress again the importance of combining in the best possible manner the different characteristics of thermal and hydro-electric plant in a mixed system. The problems involved are undoubtedly complex, and it may be possible to achieve only an approximation to the optimum design. The labour involved in achieving the closest approximation will nevertheless be well worth while, particularly if it is also possible to provide a reasonable amount of flexibility to meet future conditions. Difference of opinion between thermal and hydro-electric engineers on the design of projects is not uncommon, and may arise because of inadequate understanding by the one of the problems of the other, or because of lack of mutual appreciation of the inherent characteristics of the two types of plant. It is very much to be hoped that such difficulties will be less common in the future than they have been in the past, and that with the growth of knowledge and experience it will be possible to approach more and more nearly to optimum designs in mixed thermal–hydro-electric stations.

Discussion

The paper by Mr. Haldane and Mr. Blackstone attracted a very large and distinguished audience when it was read before a joint meeting of The Institution and The Institution of Civil Engineers on the 6th January, 1955; and although the gatherings were naturally smaller the interest was certainly no less at the meetings of the North-Western Supply Group and the South-East Scotland Sub-Centre later in the session.

The discussion in London was opened by Mr. T. Lawrie, well known for his association with hydro-electric projects in the north of Scotland. He filled in some of the details for which room could not be found in the paper, and spoke of the practical experience of operating a mixed thermal–hydro-electric scheme in Scotland. Several other speakers spoke warmly of the success of the Scottish hydro-electric schemes and paid tribute to the pioneers in the field, notably the late Colonel McLellan.

Mr. F. J. Lane gave details of a C.E.A. pumped-storage scheme in north-west Wales, and postulated some figures of load factors when nuclear stations become established. Storage and mixed systems as bases for firm output interested a number of speakers, each emphasizing some facet of the need to ensure firmness. Adding to the information given by Mr. Lane, Mr. V. G. Newman mentioned the Rheidol project in Cardiganshire, which will be a storage scheme with a wholly firm capacity.

An interesting problem in hydro-electric operation was posed by Dr. T. P. O'Sullivan when he asked about energy losses due to evaporating and silting; this does not seem to be a nuisance in Britain, but Dr. O'Sullivan cited the claim of a group in the Southern States of America to have lost 90 000 MWh through silting during a drought in 1941.

Mr. J. K. Hunter spoke of the need to amplify the term "firm power," for although the output of a thermal station is wholly firm—so long as plant and fuel are available—the degree of firmness of output from a hydro-electric station is at best an expression of probability: one can never be wholly certain that the weather will not completely upset the storage and run-off predictions. He pointed out that this had, in fact, happened in 1947–48 in Canada, and in 1948–49 in Europe; as a result, many national authorities were backing their hydro-electric stations with thermal ones.

The firmness of supply was again a subject of interest when the paper was read in Manchester, where Mr. H. Headland, in a wide-ranging contribution, mentioned the effect of both short-term and long-term weather forecasting on the operational problems in hydro-electric stations. Both he and Mr. J. F. Dunn amplified the authors' remarks on modern steel casting and welding techniques and the need for non-destructive tests.

In a written contribution, however, Mr. J. Venters has not placed much faith in weather forecasts, and gives more details of the month-to-month problems of ensuring firm output from the hydro-electric schemes in the Highlands, largely from the aspect of the relative usage and economy of hydro-electric and thermal generation in a mixed system.

The authors replied concisely and firmly to the many points raised, with obvious appreciation of the information which had been added by the contributors. Since so many had asked about firm power, they put forward the working concept that "hydro-electric power can be regarded as firm if it is capable of development in the worst conditions which can rise in 30 years."

Paper and discussion had shown the wide interest among generation engineers in the possibilities of combined thermal and hydro-electric systems, especially when the latter is associated with pumped storage. Great strides in imaginative thinking and planning have been made and much publicized on the Continent and in the United States, and proof has now been given that, in their quieter way, Scottish engineers are not merely following these developments with interest, but are in the forefront of progress.

Journal I.E.E., July 1955

GERMANIUM

F. SZEKELY, B.Sc.(Eng.), Graduate

Germanium, which was a scientific curiosity only 25 years ago, is now of great and growing importance to electrical engineers. Mr. Szekely, formerly with the British Thomson-Houston Co., summarizes here some of its properties and the processes by which it is commercially extracted and produced in a form suitable for its use in diodes, transistors and other devices. Mr. Szekely's article is based on part of his Chairman's Address to the Rugby Students' Section last year. Some of the text and the illustrations have already appeared in "BTH Activities."

DURING the Second World War efforts were made to improve the characteristics of silicon rectifiers which were used in radar equipments, and alternative semi-conducting materials were investigated. Germanium proved to be most adaptable, and whilst it did not replace silicon, the germanium point-contact diode, with its inherent high inverse-voltage characteristic, was established at the end of the war. It was followed in 1948 by the point-contact transistor and then by the "grown-junction" transistor and diode. During 1950–51 American scientists produced the "alloy-junction" diode, followed by the "alloy-junction" transistor. The difference in the methods of producing the devices will be explained later. Very recent developments have included the power diode, which, with suitable series and parallel connections, is capable of an output of over 300 kW. Other new devices are the double-base diode, the tetrode, the photo-diode and the power transistor. In the last twelve months, attention has again been focused on silicon, and silicon-junction diodes and transistors are already commercially available in the United States. These devices permit operation at much higher temperatures than germanium since they are stable up to 150°C, while the practical limit for germanium is 60–70°.

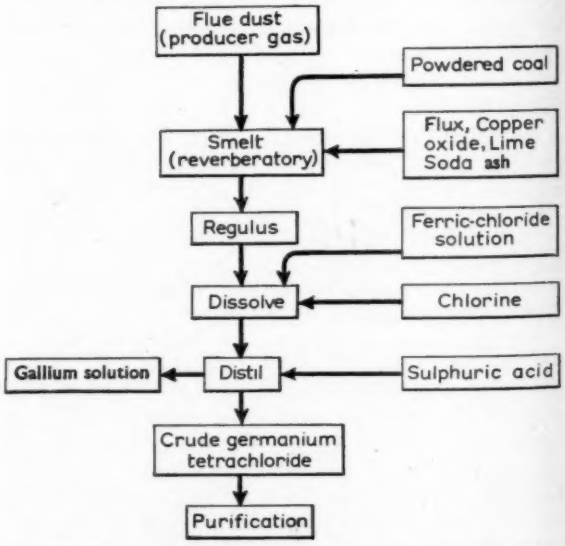
Speculation on the replacement of thermionic valves by semi-conductor devices forms the basis of many a discussion in electrical engineering circles.

Germanium, predicted by Mendeleff, was discovered by Winkler as long ago as 1886, and its chemistry was studied extensively. The advances of science during the Second World War realized and exploited the immense electrical uses, but progress was initially hindered by the difficulty of refining germanium to the degree of purity required for rectifier use.

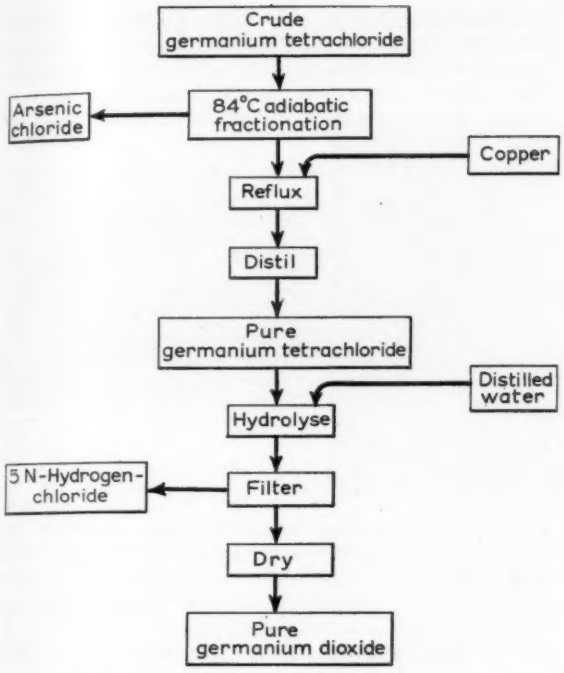
Germanium is found in the earth's crust in roughly the same proportion as zinc and lead, but the concentration is usually so low that its exploitation, unlike that of zinc and lead, is generally uneconomical. No mineral is known in which germanium is the primary constituent, but it appears in fair proportions in germanite and renierite. Germanite, essentially a copper sulpharsenide, was discovered in South West Africa at the end of the First World War and contains about 5% germanium. Renierite is a complex copper–iron–germanium–arsenic sulphide and has a lower content of germanium than germanite. It appears to be present in fair quantities in the Belgian Congo and offers more economic exploitation than germanite. Some copper, tin, iron, zinc and silver ores contain small traces of germanium but not sufficient to make the recovery of germanium alone an economic proposition. The by-products of the smelting of these ores, however, provide a source of germanium which is of commercial interest and is largely exploited in the United States.

In 1937 work at the Chemical Research Laboratory at Teddington showed the presence of germanium in the flue dust of gas-works in Great Britain, using mostly coal from Durham and Northumberland. Closer investigations revealed that only the manufacture of producer gas provided such flue dust. Approximately 0·003% of germanium appears to be present in the original coal and remains in the coke produced from these coals. Combustion of the coke under limited supplies of air, in the manufacture of producer gas, results in the germanium being driven off with the gas. If the hot gas is burned, a germanium oxide is deposited in the cool parts of the flues, thus providing a suitable British source of germanium.

The physical constants of germanium are shown in the Table. The metal is stable at 25°C and is not affected by air or water. It will however oxidize in air



1 *English process of germanium extraction from flue dust*



2 *Preparation of germanium dioxide from germanium tetrachloride*

between 600° and 700° C. Combination with chlorine takes place readily at raised temperatures, the corresponding tetrachlorides being formed. Nitric acid attacks germanium at room temperature, whereas hydrochloric and sulphuric acids have no effect. At 100° C sulphuric acid will slowly dissolve germanium. Potassium- or sodium-hydroxide solution has little effect on germanium, but the molten alkalis dissolve it.

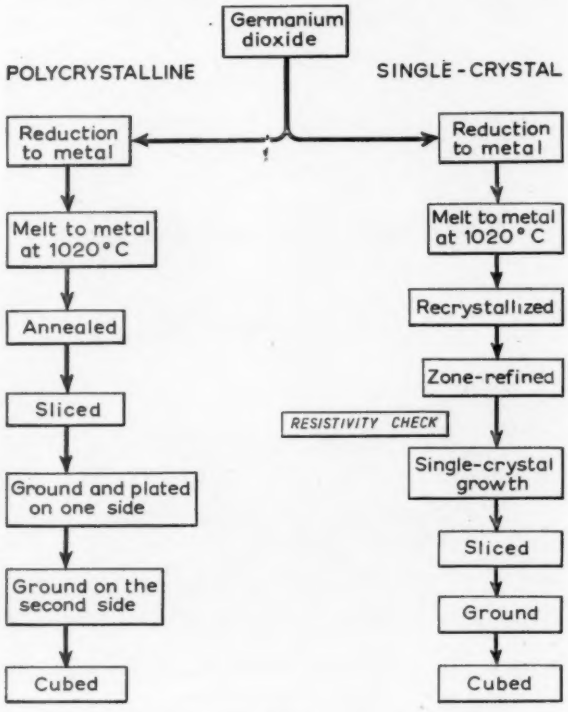
Germanium forms two oxides, whose formulae are GeO and GeO_2; the dioxide is of importance in the production of the various devices.

A number of processes are used for the extraction of germanium, each resulting in the production of germanium tetrachloride, which can then be treated to form the dioxide.

To extract germanium from zinc ores the ore is first roasted, and then mixed with salt and coal and sintered at high temperatures. The metallic impurities which include germanium are thereby volatilized, and the vapour is condensed and collected. The addition of sulphuric acid precipitates the lead which is present, as lead sulphate. Zinc dust is then added to precipitate the germanium and copper, leaving the cadmium in solution. Arsenic and other metals are also precipitated at this stage. The precipitates are filtered off, the cadmium solution is removed for concentration and finally the sludge is roasted and dissolved in hydrochloric acid. Germanium tetrachloride, with some hydrochloric acid and arsenic chloride, is distilled from this solution.

In the case of flue-dust extraction, the dust is smelted with soda ash, copper oxide, lime and coal dust to form a regulus which will contain most of the germanium. The slag is then treated with a current of chlorine under a dilute solution of ferric chloride to form germanium tetrachloride (Fig. 1). Germanium dioxide is obtained by distillation of the tetrachloride (Fig. 2).

The manufacturer of germanium devices usually obtains the "raw material" in the form of germanium dioxide and undertakes the reduction and purification.



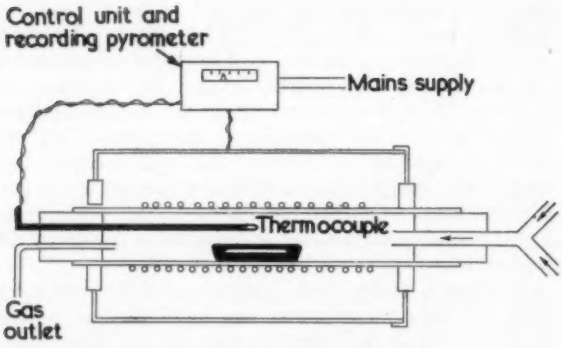
3 *Preparation of germanium from germanium dioxide*

Physical Constants of Germanium

Atomic number	32
Atomic weight	72·59
Colour	Silvery
Crystal structure	Cubic (diamond)
Density (at 25° C)	5·32 g/cm³
Melting point	958° C
Boiling point	2 700° C approx.
Volume resistivity at 25° C	60 × 10^6 microhm-cm

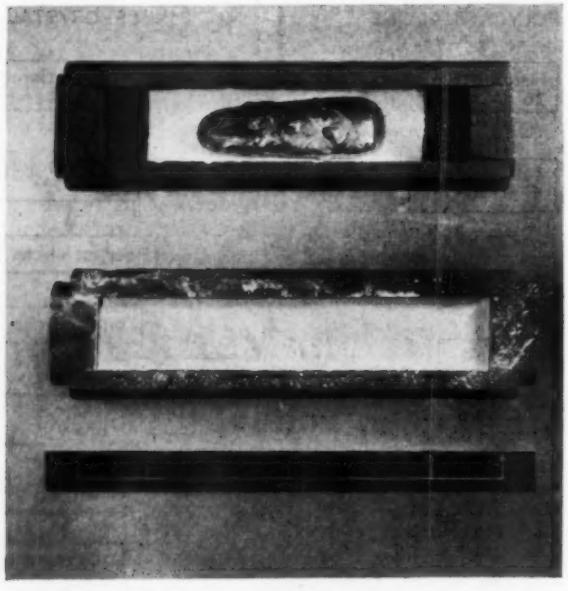
The present price of germanium dioxide is about 2s. 3d. per gramme. For point-contact devices, polycrystalline material is used largely for economic reasons, but junction devices require single-crystal material.

The initial reduction processes are similar and are illustrated in Fig. 3. The dioxide is loaded into graphite



4 *Germanium dioxide reduction furnace*

boats and reduced, in a horizontal furnace, in a stream of hydrogen at approximately 650° C (Figs. 4 and 5). It is next heated quickly to 1020° C and kept in the molten state for half an hour. Subsequently the material is cooled and annealed at 500° C for 2–3 hours.

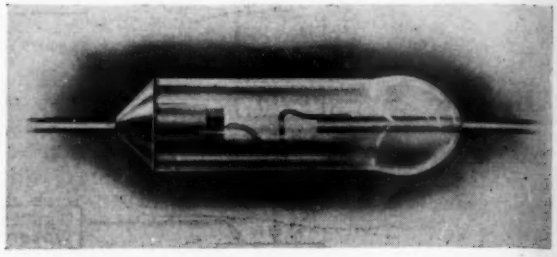


5 *Reduction of germanium dioxide*

Top: A germanium ingot in a graphite boat.
Bottom: The germanium dioxide from which the ingot is produced.

With polycrystalline material, the ingot, after further cooling, is sliced; approximate dimensions of the slices are 1·5 cm × 1·5 cm × 0·076 cm. One surface of the slice is ground and plated for soldering to a heat sink. Reference to Fig. 6 will help to explain this and other terms used in describing germanium rectifiers.

The photograph shows a typical design of a germanium point-contact rectifier. The body consists of a small glass tube (the overall length of the device, excluding the leads, is approximately $\frac{9}{16}$ in) which is sealed at one end. The negative connection passes through the seal and carries the fine chisel-shaped catswhisker made of

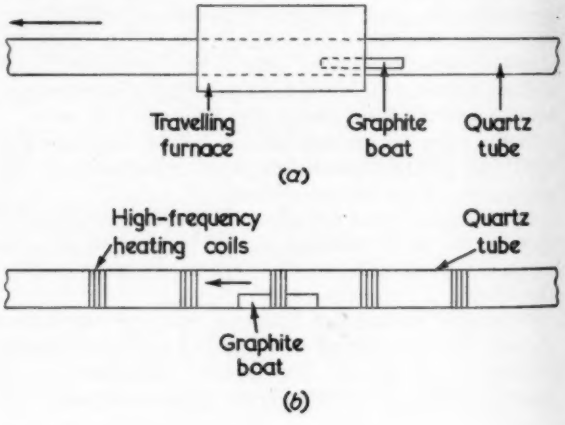


6 *Point-contact diode*

tungsten wire. A brass block, to which is soldered the small germanium polycrystalline flake, forms a seal at the other end of the tube. The brass block serves as a support for the germanium and also helps to dissipate the heat generated in the germanium.

The opposite surface of the slice, which will make contact with the catswhisker, is next ground, after which the slice is cut or broken into many cubes, each approximately 0·1 cm square, for use on the production line.

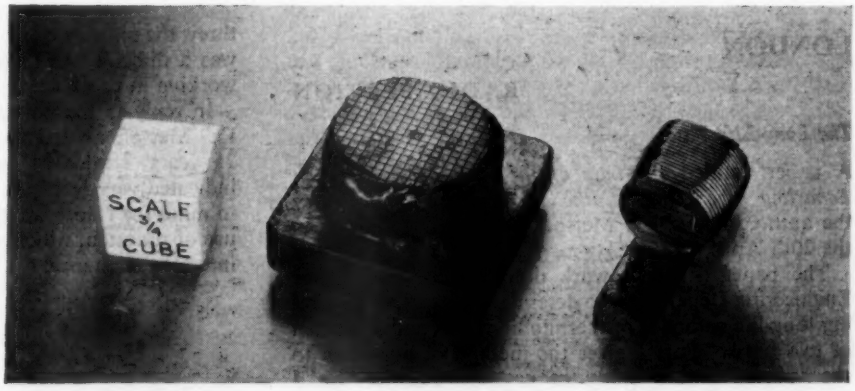
For the production of single-crystal material, the first two stages are similar. The metal contained in the graphite boat is then placed in a travelling furnace and



7 (*a*) *Recrystallization.* (*b*) *Zone refining*

again brought to a molten state [Fig. 7(*a*)]. The furnace is slowly drawn over the boat, with the result that one end will begin to cool and solidify. The impurities in the germanium remain in the liquid state and are therefore collected at one end of the ingot. A similar process [Fig. 7(*b*)], referred to as "zone refining," is then carried

out. During this the boat passes through several heating stages, and in each a molten zone "travels" through the ingot, collecting further impurities at one end. After the first completion of the zone refining a resistivity check is made. Further zone refining may be required, dependent on the device for which the material is required. The impure sections of the ingot are cut off at each stage and returned to the crystallization furnace or to the dioxide supplier for reclamation.



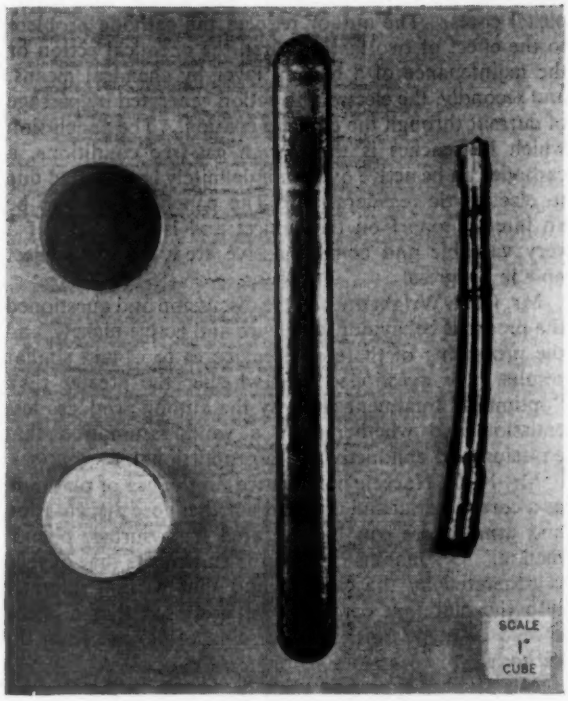
8 *Slicing and cubing of single-crystal material*

Eventually the germanium of required purity is again melted in a crucible and held at a temperature a few degrees above the melting-point. Single crystals are drawn from the melt by immersing the end of a single crystal seed and slowly withdrawing it, the operation normally being carried out in an inert atmosphere. The temperature of the melt and the speed of withdrawal determine the diameter of the crystal so produced. The crystal is then sliced, ground and cubed (Fig. 8).

The *p–n* junction of a junction rectifier may be formed either by a diffusion (or alloying) process or by "growing" several junctions when pulling the single crystal. In the first method the appropriate impurity is placed in direct contact with the germanium and the assembly is heated until the impurity, by softening, diffuses into the germanium. A unit is thus produced in which both *p*- and *n*-type germanium are combined to form a junction rectifier. In the second method, germanium containing the appropriate impurity is repeatedly added to the melt during the single-crystal pulling, so that *p*- and *n*-type germanium are alternately predominant, and a number of *p–n* junctions are thus obtained from each crystal.

The current/voltage characteristics of germanium depend largely on the amount of impurities present. Control of the impurity content has reached a fairly satisfactory stage, and production can be achieved with a limited spread of characteristics. The acceptor or donor impurities, to produce *p*- and *n*-type germanium, can be added during the initial germanium-dioxide reduction or during the final melt from which single-crystal material is produced.

More and more electrical engineering problems are being solved by the use of germanium devices, and considerable advances, not only in the development of new devices, but also in the processing and manufacturing fields, can confidently be expected.



9 *Steps in single-crystal reduction*

Top left: Flue dust. *Centre:* Polycrystalline ingot. *Bottom left:* Germanium dioxide. *Right:* Single crystal.

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HOME EVENTS

LONDON

RADIO SECTION

The Long-Life Valve

A paper entitled *A Study of the Long-Term Emission Behaviour of an Oxide-Cathode Valve* was presented by the author, Dr. G. H. Metson, to a large audience on the 20th April, 1955.

The paper describes work done by the Post Office Engineering Department to determine the factors governing long-life cathodes of thermionic valves and is written in two parts. Part 1 gives the method of approach to the subject, and a study of cathode emission on a platinum-core cathode: Part 2 explores the emission characteristics of cathodes on both passive and active nickel cores. The author reduces the cathode problem to the effect of two factors: first, the chemical action or the maintenance of a barium layer by chemical means, and secondly, the electrolytic action generated by passage of current through the cathode coating. The conclusion which he reaches is that, given gas-free conditions, a cathode can be active over an indefinitely long period due to electrolytic regeneration. The paper is stated to be an interim report on the subject and is indicative of a very valuable and comprehensive study of the subject now in progress.

Mr. D. A. Wright opened the discussion and questioned the reported behaviour with pure and active nickels, and the processing of these different cores to obtain similar results. He questioned also whether the greater than "optimum" treatment cited by the author produces less emission and whether it is a valid assumption that emission and conductivity are proportional.

Mr. H. G. Haegele commented on the use of platinum as a core material and doubted whether core dispensation and atmosphere can be separated from surface phenomenon. Dr. Jenkins queried the statements that oxygen is generated by the cathode and that barium migrates into the platinum core, and he proposed that a check should be made on the evaporation of barium from the cathode.

Mr. Hughes expressed some anxiety as to the application of the results to commercial valves in view of his experience that the mutual conductance can change violently in the first 100 hours even under good processing conditions. This was the parameter used by Dr. Metson for determining his emission goodness, and the basic criterion for his work was stability of mutual conductance with life.

Monsieur Bonan, from Paris, gave his comments on interface measurements and quoted results on platinum filaments after 150000 hours in service.

No general discussion ensued when the Chairman threw the meeting open, it being apparent that the subject was a difficult one for discussion except by the experts working in this field.

In reply to the points raised by the various speakers, Dr. Metson quoted the results of tests on valves after 25 years' service at one of the repeater stations and indicated very briefly the variations in core metal he has in mind for future work in this field. These include the use of tungsten, which might result in the elimination of interface resistance.

L. R.

UTILIZATION SECTION

Ten Million Batteries

At the meeting on the 5th May, 1955, the Annual Lecture of the Utilization Section was given to a large audience by Dr. W. Grey Walter, who took as his subject *The Electrical Activity of the Brain*. He emphasized that the brain was an organ of quite fantastic complexity, there being some 10000 million nerve cells, any or all of which might be in communication with any or all of the others. The problem facing the physiologist was illustrated by the lecturer in the following striking manner. Imagine five planets, each inhabited by 2000 million beings, with a telecommunication system in existence so that any one being could speak to any of the others, and then imagine also a being from an entirely different planet, who does not even know their language (or languages) or the technical layout of their telecommunication system, trying to evolve some method whereby he can understand the messages which are passing between such beings. From this analogy, it is clear that, however elaborate the measuring equipment of the research worker may seem, its complexity is as nothing compared to the problem which it was intended to approach. Each cell is a miniature battery, and, by means of electrodes placed on the scalp, these voltages are picked up and the activity of the brain thereby can be studied. As regards recording or display devices, which have to be designed to present information on brain activity from many regions, one tendency is towards using more and more channels of amplification and recording, 15 channels being quite common and as many as even 100 having been used simultaneously, while another tendency is the diminishing scale of the apparatus. Dr. Grey Walter felt that we were at the end of the epoch of thermionic amplification and at the beginning of a new epoch of transistor amplification. The future for recording devices seemed to lie in the development of a very small unit of some 30 channels, which would be portable by a single man. He instanced that a possible development might be the design of a pocket-size equipment, which a normal person under study could wear in the same way as a

deaf aid; the record obtained from this would enable a study to be made of brain activity during normal everyday life, which often is very different from that recorded while the subject was in the laboratory.

The lecture was admirably illustrated by numerous lantern slides, and some of the equipment used by the research worker was demonstrated. The appreciation of the audience of the very lucid and fascinating way in which Dr. Grey Walter had dealt with such a highly complicated subject was shown by the acclamation which accompanied the vote of thanks to him.

Radiation in Berkshire—but not Solar

A party consisting of 165 members and ladies, took part in the Summer Visit of the Section on May 21st. They assembled in the morning at the Atomic Energy Research Establishment, Harwell, and, while members were being shown round the Establishment, the ladies were taken on a coach tour in the surrounding district, being entertained to morning coffee by the Southern Electricity Board.

Among the items seen by members during the tour of the Establishment were the British Experimental Pile (BEPO); demonstrations of the handling of radioactive isotopes and the applications of these materials; demonstrations to illustrate health hazards; precautions and monitoring procedures; the Linear Accelerator Laboratory; the engineering services associated with a "hot" chemical laboratory; the Cyclotron Laboratory; and a demonstration of geological and mining apparatus.

The whole party then met for lunch in the canteen of the Establishment, where the Chairman of the Section, Mr. J. I. Bernard, expressed thanks to the Director of the A.E.R.E., Sir John Cockcroft (who was unfortunately unable to be present), for the excellent arrangements made in connection with the tour. Dr. Denis Taylor, on behalf of Sir John, expressed his pleasure at the presence of the members of the Section and their ladies.

After lunch the party were shown the new lecture hall (to be known as "The Cockcroft Hall"), and then left by coach for Goring to make a trip on the river to Wallingford, where the Visit concluded with high tea at the Castle Priory Hotel.

Notwithstanding the heavy showers during part of the day and the somewhat chilly conditions on the river trip in the afternoon (one member was heard to remark that a pocket-size atomic pile would have come in handy to raise the temperature), all those taking part in this Summer Visit agreed that it had been an instructive and enjoyable function. R. H. R.

DUNDEE

SCOTTISH CENTRE

The last function of the 1954–55 session, the Annual General Meeting, took place on May 26th in Dundee, when the Annual Report was read, the accounts were laid open for inspection and the names of the Chairman (Dr. E. Wilkinson of Aberdeen) and the Committee for the next session announced. After the formal business Mr. J. H. P. de Villiers, having unearthed from the archives of Savoy Place the Institution Coat of Arms for Scotland, showed it for the first time to members of the Centre and gave an explanation of the differences between the Scottish and English versions. Mr. J. S. Hastie, the Chairman of the Centre, then delivered his Chairman's address on *Factory Testing of Impregnated-Paper-Insulated Cables*. Mr. Hastie mentioned the tests that may be carried out during manufacture but dealt more particularly with tests on the finished cable; included in these were the measurement of cable parameters, mechanical tests, heat cycles, power-factor determination and, finally, overvoltage and impulse tests. Once again Mr. Hastie demonstrated his unbounded enthusiasm for cables and held his audience fascinated to the end. E. O. T.

NEWS *from abroad*

LAGOS AND ACCRA

WEST AFRICAN
JOINT OVERSEA GROUP

The West African Joint Oversea Group was formed in 1953 under the Chairmanship of Mr. A. McDonald, then the Inspector-General of Public Works in Nigeria and now the Secretary of The Institution of Civil Engineers. The present Chairman is Mr. J. Houston Angus, Chairman of the Electricity Corporation of Nigeria.

To date the majority of the Group's activities have been centred on Lagos, where there is by far the largest concentration of members of the three Institutions, but some functions have been arranged up country in Nigeria, and there is a local committee operating from Accra in the Gold Coast.

As is necessary in a Joint Group, the papers given and the visits made have covered a very wide range of subjects; whilst maintaining a high standard they have concentrated on the practical application of engineering science and economics rather than on the more abstruse problems of research and design. A number of papers have been given on electrical subjects, notably one on the new

Ijora "B" power station under construction in Lagos, and another entitled *A Survey of Electrical Installation Practice in Nigeria.*

One of the major concerns of the Group has been the training of professional engineers in Nigeria, and the Committee of the Group have been in constant touch with the Councils of the three Institutions and with the local education authorities regarding the establishment of an Engineering Faculty at the Nigerian College of Arts, Science and Technology.

In connection with this aim, the Secretary of The Institution recently visited West Africa. Mr. Brasher spent a week in Nigeria and attended both the Annual General Meeting of the Group and its Annual Dinner. Dr. C. A. Hart, the Principal of the College, gave a talk on the training of engineers in West Africa after the Annual General Meeting, and a very lively discussion ensued. This topic was continued at the Annual Dinner, held the next evening at the Ikeja Arms Hotel, at which Mr. Brasher emphasized the need for the widest possible background in an engineering course. As a result of his visit it is hoped that agreement will be reached between the Nigerian College and the Councils of the three Institutions on the standard of instruction required, in order that the courses given by the College may be recognized by them and the students allowed to sit for the Institutions' examinations.

In a territory such as West Africa, where there is a grave shortage of professional engineers and their recruitment from oversea is a matter of difficulty, the establishment of a supply of locally trained engineers, provided they have sufficient background of practical training and field experience, will be invaluable.

The Group's activities are continuing and expanding with meetings and visits monthly. It may be truly said that this Group, the youngest of the component bodies of the three Institutions, is very much alive and is providing an invaluable meeting ground for engineers whose work brings them to West Africa. K. H. W.

NEW SOUTH WALES

Power—Steam and Nuclear

On the 2nd March, 1955, Mr. C. E. H. Verity gave an address entitled *Modern Trends in Power-Station Construction in Great Britain*, to a joint meeting, attended by 120 members, of The Institution and The Institution of Engineers, Australia. Mr. Verity outlined the achievements of the Central Electricity Authority in power-station construction since Vesting Date and showed how the programme had been arranged as a continuation of earlier plans laid down by the independent authorities. Aspects of efficiency, plant capacity and demand growth were emphasized, and the trend towards larger machines and higher steam conditions was discussed. The meeting took place at Science House, Sydney.

On April 5th members of The Institution in New South Wales were invited to attend a meeting in the Stawell Hall, Sydney, which had been arranged by the Mechanical Engineering Branch of The Institution of Engineers, Australia, to hear an address by Mr. A. L. G. Lindley on *Nuclear Engineering*. Mr. Lindley outlined the more important principles that entered into the subject and gave details of how British industrial firms are participating in the development of nuclear reactors and nuclear power stations. He stressed the need for adequate facilities for the training of nuclear engineers, who in the next decade would be in great demand. Professor Myers, in the discussion following the address, described steps already taken in New South Wales to meet this need. J. T. R.

UNITED STATES OF AMERICA

As far as the writer is aware, this is the first time that the Honorary Secretary of The Institution in the United States of America has been privileged to present, for inclusion in the *Journal*, an article of general interest to members on the activities of The Institution's sister societies in the United States. The range of operations and subjects covered by the many American engineering societies are so extensive that it is difficult, even when considering the electrical field alone, to select the matters of outstanding interest, but it is hoped that the following few items will have some appeal to members.

The American Institute of Electrical Engineers and the Institute of Radio Engineers have a great many activities scheduled from three to twelve months in advance, and future reference in the *Journal* to forthcoming American events will normally be made only to affairs of very great importance. Any member contemplating a visit to the United States can, upon written request to Mr. R. H. Barclay, The J. G. White Engineering Corporation, 80 Broad Street, New York 4, N.Y., U.S.A., be furnished in advance of his visit with information on future activities occurring within the period of his visit.

Both the 1954–55 Mid-Winter General Meeting of the A.I.E.E. and the Annual Meeting of the I.R.E. are now matters of history—4 652 people attended the former, and 39 800 the latter. The Radio Engineering Show, which was part of the Radio Institute's Annual Meeting, was held in the Kingsbridge Armory and Kingsbridge Palace and displayed radio and associated equipment in over 700 exhibits. It was the largest show of its type that has ever been held, and many new products and processes were shown.

The major engineering societies in the United States, who have had their headquarters for about half a century in the Engineering Society's Building, at 33 West 39th Street, New York, are struggling with the problem of where to establish a new headquarters of sufficient size to accommodate their greatly enlarged activities—either in New York or some other large metropolitan area. The present building was given to the societies by Andrew Carnegie and one of the conditions of his bequest was that the technical libraries of the engineering societies

should be housed therein. These were all consolidated and are now operated as a department of United Engineering Trustees (the titular owner of the building) under the direction of a Library Board, whose membership includes representatives of the four "founder" societies—A.S.C.E., A.I.M.E., A.S.M.E., and A.I.E.E.—the societies' Secretaries, representatives of the Trustees, and the Director of the Library.

Last fall American engineers were pleased to welcome President Eccles, who was attending the Fiftieth Anniversary Celebration of the I.E.C. He joined Mr. Barclay and Mr. Nelson Hibshman, Secretary of the A.I.E.E., at luncheon in the Engineers' Club, after which Mr. Hibshman took Mr. Eccles into the Engineering Society's building (which adjoins the Engineers' Club), and showed him over the A.I.E.E. quarters.

The Honorary Secretary in the United States has also had the pleasure of receiving personal calls from quite a number of other prominent members of The Institution. He hopes that any other members who contemplate visiting the United States will call on him, and he stands ready to contribute suggestions or advice to such visitors in the hope that it will facilitate the conduct of their business and make their stay more profitable and pleasant.

R. H. B.

OVERSEA ATTENDANCE REGISTER

During the period 1st May to 31st May, 1955, the following members called at the Institution Building and signed the Attendance Register of Oversea Members:

BEWICK, R., B.Sc.(Eng.) (Bellville, S. Africa).
CARRUTHERS, P. O., B.E. (Bombay).
COTTERILL, L. J. (Kuwait, Persian Gulf).
COWEN, A. B., O.B.E. (Salisbury, Southern Rhodesia).
GURTU, R. K., B.Sc. (Bombay).
HALFTER, H. P. (Takoradi, Gold Coast).
INGLIS, F. K. (Accra).
JOBLING, H. B., M.B.E. (Johannesburg).
KATZ, L., B.A., M.Sc.(Eng.) (Durban).
MAGLIONE, R. V. (Dar-es-Salaam).
MORTON, J. R., B.Sc.(Eng.) (Kuala Lumpur).
NAPPER, C. G., B.Sc.(Eng.) (Dar-es-Salaam).
PATVARDHAN, U. K. (Bombay).
PENGELLY, I. E. (Sydney).
PUGSLEY, E. R. J., B.Sc.(Eng.) (Accra).
ROSSLER, A. (Cradock, S. Africa).
SUTHERLAND, D. G., B.Sc. (Pietermaritzburg, S. Africa).
WILLIAMS, J. W. M. (Nairobi).

Oversea members will be interested by the two announcements on page 490 of this issue. In addition, short articles, items of news and photographs from them will be welcomed by the Editor of the Journal.

The Radio Section discuss

DOMESTIC TELEVISION RECEIVERS

On the 13th December, 1954, Mr. W. L. Greenwood opened a discussion on "Practical and Economic Problems in the Maintenance of Domestic Television Receivers" at a meeting of the Radio Section. A summary of his remarks, and of the subsequent discussion, appears here.

MR. W. L. GREENWOOD began by saying that the practical and economic problems in the maintenance of television receivers are largely determined in the design and development stages of new models. It is therefore essential for all designers, development engineers, and component manufacturers to be "maintenance minded." To this end he suggested that all engineers who intend to apply their knowledge to the design and development and manufacturing side of the industry, should spend part of their training period in the maintenance side of the industry, to see at first hand the problems which shortcomings in design and manufacture can create.

The greatest problem in the maintenance side is that of personnel. The complexity of television design demands a high standard of technical knowledge and an extensive practical training. The maintenance engineer must be a good technician, a good practical engineer with a natural flair for fault-finding and, when meeting the set owner, a good retailer's and manufacturer's representative. This last qualification appears to be overlooked in training schemes and qualifying examinations for maintenance engineers.

Mr. Greenwood said that there had for some time been a shortage of good engineers in the retail side of the industry, and he suggested that one way of making retail servicing more attractive to the right type of engineer is to divorce the working hours of the maintenance engineer from those of the shop assistant.

The periods of guarantee of three months for valves, six months for cathode-ray tubes, and one year for television receivers, are quite arbitrary, and the failure of components just outside these guarantee periods are an embarrassment to the industry. Owing to its complexity and the high unit cost of certain vulnerable components, television maintenance is necessarily expensive. Moreover, the maintenance costs tend to be very unevenly distributed between set owners.

These factors make a good case for the provision of

maintenance schemes at fixed annual charges. It has been found that retailers can operate maintenance schemes covering all types of failure at a charge to the owner of under £10 a year. To be successful, maintenance schemes must run on highly efficient lines, and when they are, they are highly satisfactory to the operator of the scheme and to the participants. The owners of the few really troublesome receivers feel that they are getting good value from their maintenance contracts, and those with trouble-free receivers are also quite satisfied, particularly if they are offered a nominal "no claims" bonus.

Service work in this country is normally done by retailers with the backing and assistance of the receiver manufacturers. There are, in addition, a few "trade service" organizations who more or less take over the role of the manufacturer, but Mr. Greenwood felt that the manufacturer is better placed to support the dealers' maintenance units, and there is little need for these trade service organizations.

The provision of suitable training for maintenance personnel is a major problem, particularly in the rural areas. A quite important part has been played in this training programme by the television training schools set up by most leading receiver manufacturers.

The developing of a maintenance unit from a small dealer in radio only to a large one handling television and radio receivers, in addition to the personnel training referred to above, presents problems of space, component stock and test equipment. The component stock problem could be eased by some measure of standardization, particularly in the matter of valves and cathode-ray tubes. Stocks of these items represent a considerable tied-up capital and valuable space, and although he appreciated that some new types must be introduced in the interests of progress, Mr. Greenwood felt that a greater measure of standardization could be achieved.

The test equipment for television maintenance need not be much more elaborate than that used for radio-receiver maintenance. The chief additional items required are a pattern generator and an e.h.t. measuring device. The pattern generator, although not essential, is a great help in maintaining the efficiency of the department. For e.h.t. measurement, Mr. Greenwood suggested that the electrostatic meter is too fragile and too expensive for general maintenance use; spark-gap devices are too crude and sometimes dangerous in use, and the best solution is probably a loading resistor for use with a standard multi-range meter.

Mr. Greenwood then looked ahead to colour television, and gave the opinion that there will be greatly increased complications and problems for the maintenance side of the industry, but that these will also provide greater interest and opportunity to those who take up maintenance work.

In the ensuing discussion the first contributor expressed concern at the enormously increased rate of production of television receivers, which has not been matched by a corresponding growth of servicing facilities, although this is gradually being offset by improvement in the reliability of receivers. He emphasized that, from the point of view of the dealer, reliability is more important than ease of servicing. Some 70–90% of receiver faults—a figure confirmed by other speakers—are still to be attributed to valves and cathode-ray tubes, and some manufacturers are prone to introduce new valve designs too freely. The scheme for receiver maintenance at a fixed charge outlined by the opening speaker was criticized as being almost twice as costly to the dealer as normal servicing.

Another speaker was alarmed at the poor prospects offered by television servicing as a career, many able servicemen whose skill should be employed in diagnosing faults being compelled to spend a great part of their time performing simple repairs. He advocated the setting up of servicing companies where specialized servicing would be concentrated and no longer dispersed uneconomically among a large army of small dealers. This problem would become more acute with the advent of colour television, and it was also suggested that women might be employed on the more routine repair work. Some speakers favoured increasing the number of "plug-in" components in receivers to assist ease of servicing. Representatives of manufacturers, however, pointed out that practice shows this to lead to unreliability, as the plug-in units themselves are frequently the source of faults, and moreover introduce undesired capacitance. Indeed, trends are in the opposite direction as is evidenced by development work on wired-in valves. It was generally agreed that improvements in means for withdrawing receivers from their cabinets are essential.

On behalf of the retailers the economic problems of servicing were claimed to be paramount by a speaker, who instanced the growing number of dealers who deliberately refrain from providing service facilities owing to the cost of workshop space and equipment, the need for storage of an ever-increasing number of spares, transport difficulties and restricted hours of television test transmissions. Another speaker maintained that speed of service was all-important from the customer's point of view, and that this would not be forthcoming from the larger servicing organization. It was suggested that more effort be devoted to "selling" service and that a parallel exists with the motor-car industry. By so doing the customer's confidence would be won—too many retailers are regrettably prone to remain silent on the need for subsequent servicing of their receivers. In his summing up of the discussion, Mr. Greenwood expressed the view that the opportunities for the would-be serviceman are by no means as uninviting as had been suggested. Retail businesses show a steady tendency to expand and their proprietors are becoming more and more conscious of the need for efficient and skilled service personnel. There is room for considerable improvement in the premises and servicing equipment available.

Surface Roughness in Waveguides

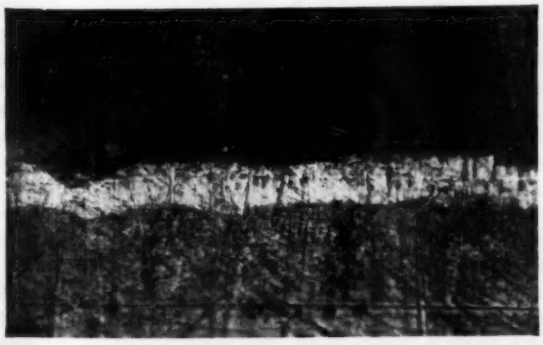
A DIGEST OF A RADIO SECTION PAPER (No. 1785) ENTITLED "SURFACE ROUGHNESS AND ATTENUATION OF PRECISION-DRAWN, CHEMICALLY POLISHED, ELECTROPOLISHED, ELECTROPLATED AND ELECTROFORMED WAVEGUIDES," BY J. ALLISON, B.SC.(ENG.), GRADUATE, AND F. A. BENSON, M.ENG., PH.D., ASSOCIATE MEMBER. THE FULL PAPER WAS PUBLISHED IN MARCH, 1955, IN PART B OF THE PROCEEDINGS.

REPORTS of unexpectedly high attenuation in certain conductors at microwave frequencies have been published by several independent investigators. It has been concluded from a series of measurements on copper, brass and electroplated waveguides, that the discrepancies between theoretical and experimental performances are due solely to surface roughness.

The paper describes detailed examinations of the roughness of various good waveguide surfaces. A section of the guide is electroplated, set in a plastic mould and, after being polished, is microscopically examined. Measurement of the total length of the interface between the waveguide and the protective plating allows the calculation of the roughness coefficient for that surface.

The surface finish of precision-drawn tubing is quite adequate for most applications, but it may be improved, if desired, by careful chemical or electrolytic polishing, or electroplating in bright baths under closely controlled conditions.

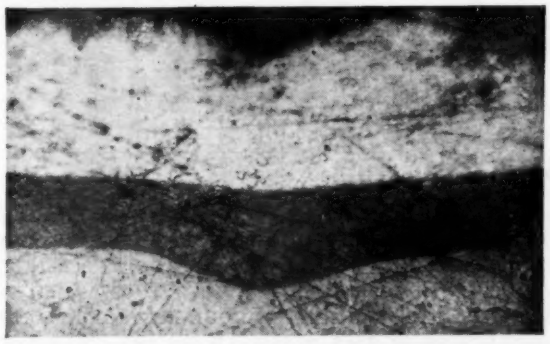
Surfaces from transverse sections of precision-drawn 3cm copper waveguides are deformed by shallow "draw lines." Fig. 1 shows a typical transverse section taken from a short side. Longitudinal-section surfaces of all drawn tubes are much smoother than transverse-section ones. Precision-drawn brass waveguide is the best of all drawn tubes examined and leaves little to be desired so far as its internal roughness is concerned.



1 *Typical photomicrograph of precision-drawn copper waveguide surface from 1 in × ½ in guide*

Section perpendicular to waveguide axis; magnification 500; copper in the lower part of the photograph.

Chemical polishing, using solutions based on phosphoric-acid mixtures, seems to be more effective on precision-drawn copper tubes than on brass ones, because of their original roughness, although it can be usefully employed on brass waveguides. Such polishing eliminates the microprofile, but the general macroprofile remains and would be difficult to eliminate without removing a considerable amount of metal from the surface.



2 *Typical photomicrograph of copper-electroplated brass waveguide surface from 1 in × ½ in guide*

Section parallel to waveguide axis.
Magnification 500; brass in the lower part of the photograph, bright-copper plating in the dark bands and the protective coating of silver at the top.

Electropolishing removes all microscopic roughness. Electropolished copper waveguides have small pits in the surface about 0·0001 in deep, probably caused by inclusions of copper oxide. This technique is not so effective for brass as for copper waveguides. The optimum voltage in an electropolishing bath is very critical, higher and lower voltages producing pitting and etching respectively.

Measurements on bright-silver-plated waveguides gave somewhat disappointing results. The internal surface finish is always considerably better with a bright bath than with an ordinary cyanide one, but sometimes the plating has no levelling action. Bright-copper plating is smoother than a bright-silver deposit and exhibits greater levelling properties (Fig. 2).

Information on the surface finish of electroformed copper waveguides is presented in the paper. The finish depends very largely on the type of mandrel employed and the method of separation of the waveguide from the mandrel. Stainless-steel mandrels give much better

surfaces than alloy ones. With a well manufactured stainless-steel mandrel it is possible to electroform copper waveguide which has a better surface finish than any other kind of waveguide.

Formulae for calculation of the attenuation of any H or E mode in a rectangular waveguide, taking account of surface roughness, have been developed from the original Kuhn* expressions, by the introduction of three additional factors. A simple method for determining precise values of these surface-roughness factors has been evolved. In this way the difference between actual and theoretical attenuation values, and thus an accurate value for the actual attenuation, can be predicted by calculation without the need for careful measurements on very long lengths of tube using special test equipment.

* KUHN, S.: "Calculation of Attenuation in Waveguides," *Journal I.E.E.*, 1946, 93, Part IIIA, p. 663.

Solid Insulation

A DIGEST OF A STUDENTS' PAPER ENTITLED "SOME FACTORS DETERMINING THE PERFORMANCE OF SOLID INSULATION," BY MISS M. K. WESTON, B.SC.(ENG.), ASSOCIATE MEMBER. THE PAPER WAS AWARDED A STUDENTS' PREMIUM BY THE COUNCIL, AND A LONG ABSTRACT OF IT WAS PUBLISHED IN THE STUDENTS' QUARTERLY JOURNAL, MARCH, 1955.

FAILURE OF INSULATION is caused mainly by one or more of three conditions, namely high electric-stress concentration, ingress of water or excessive temperature. Some of the well-established mechanisms by which these cause failure are described in the paper.

Effect of High Stresses

Internal Discharges.—When an alternating voltage is applied to insulation containing an air pocket or void the voltage across the latter is determined by capacitive division. Therefore the stress in the void is approximately equal to the average stress multiplied by the permittivity of the insulation. This permittivity always has a value greater than 2, and quite frequently it has a value of 9. Discharges may therefore occur in the void at low average stresses. If the energy of the discharge causes the material to decompose so that a conducting layer is formed across the surface of the void the voltage across the void is reduced, and the discharge energy loss tends to be replaced by a conduction energy loss. Alternatively decomposition may only be local where the discharges impinge on the solid, and may result in the formation of a low-resistance or conducting path. The path may then progressively extend through the dielectric by intrinsic breakdown at the tip.

Whether internal discharges are permissible in any particular equipment is largely based on experience. In solid-type cable used at voltages of up to 66 kV between phases, voids are always present after the first heat cycle, but in capacitors, where the dielectric is thinner and more highly stressed, it would appear that no discharges are tolerable.

The standard method of detection of internal discharges has been to obtain a measure of the energy loss by measuring the power factor at increasing voltage. However, the sensitivity of detection has been increased by a factor approaching 1 000 by electronically detecting the onset of the h.f. impulses generated by the discharges in the charging current.

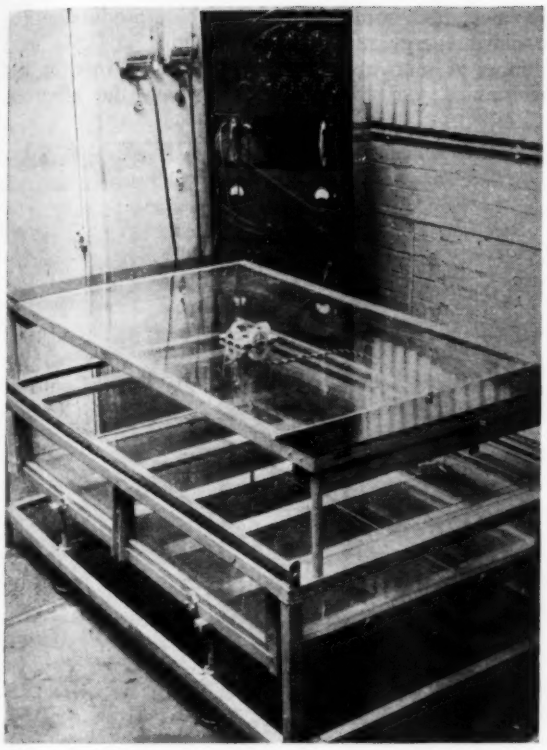
External Discharges.—Discharges can also occur between the metal parts of equipment and the surface of insulation on other parts at a different potential. These external discharges may initiate high-voltage tracking or cause total puncture of the insulation on which they impinge.

If discharges cannot be eliminated by changes in design, or are still present on over-voltage tests, a semi-conducting coating may be used to provide a uniform conductivity low enough to prevent discharging spots, yet high enough to prevent conduction losses. Examples are semi-conducting glazes on ceramics, and graphite coatings on the slot portions of alternator coils.

Thermal Instability.—Thermal instability can arise only when a dielectric cannot dissipate the heat from the regions in which it is generated. At power frequencies, high stresses or considerable deterioration are necessary to provide this condition at normal working voltages. The heating effect may be produced by conduction currents due to ionic dissociation, or, on alternating current, to local ionic or dipolar movement. These losses increase steeply with rise in temperature. Generally, thermal instability is only of importance when the losses in the insulation form a considerable part of the total amount of heat generated locally. It is therefore of major concern in cables and capacitors, and to some extent in the bushings and loads of transformers.

Electrochemical Deterioration.—Electrochemical deterioration is sometimes incorrectly associated only with unidirectional or direct voltages. However, it can occur at power frequencies. In capacitors with chlorinated impregnants, where the high permittivity leads to greater dissociation, some of the fluid or impurities dissociate to form hydrogen ions. These are discharged at the cathode to form nascent hydrogen, which combines with the fluid to form hydrochloric acid which in turn attacks the foil and paper. The absorption of this hydrogen by a hydrogen acceptor will prevent cumulative ionization. Church and Garton found that the addition of 2% azobenzene at least doubled the life under d.c. stress and in some cases increased it by a factor of 50.

Detection of High Stress Concentrations.—The stress distribution in equipment is often readily examined by immersing a model in an electrolyte so that the capacitance of the insulation is simulated by the resistance of the electrolyte. Different permittivities are represented by appropriate changes in depth of the electrolyte, and the necessary abrupt changes in current density at the



1 *A modern electrolytic tank*

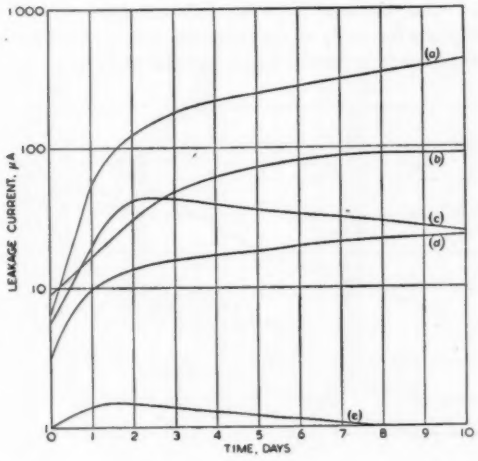
boundaries are ensured by using closely spaced conducting pins. Fig. 1 shows a modern electrolytic tank.

Ingress of Moisture

The ingress of moisture into equipment can only be totally prevented by hermetic sealing, but as this is not usually a practical proposition, varnish is used to delay the rate of ingress. The rate of moisture absorption of a material is, however, of less importance than the amount of substance in the material which will give rise to chemical or electrochemical action when moisture has been absorbed and cumulatively increase the leakage current. The high dielectric constant of water promotes a condition favourable to the ionization of particles introduced into it.

One method of determining the presence of such ionizable material is to measure the conductivity and pH-value of an aqueous extract. A more direct method for sheet material is to clamp it between two cup-like electrodes filled with water. A d.c. stress is then applied and the leakage current measured. Fig. 2 shows the results obtained on various fabrics coated with the same alkyd varnish.

The detection of moisture in insulation is obviously of the greatest importance, and a great deal of work has recently been done on the basis of dielectric absorption. This has resulted in the E.R.A. dispersion meter, which is suitable for factory use.



2 *Curves showing the results obtained on various fabrics coated with the same alkyd varnish*

(*a*) Cotton.
(*b*) Nylon.
(*c*) Glass.
(*d*) Silk.
(*e*) Terylene.

Effect of Temperature

The importance of the operating temperature of electrical equipment may best be illustrated by the fact that insulating materials are classified into groups with maximum permissible working temperatures. There is nothing fundamentally critical about these temperatures; they are based on experience and laboratory tests which indicate that an acceptable life is then obtained.

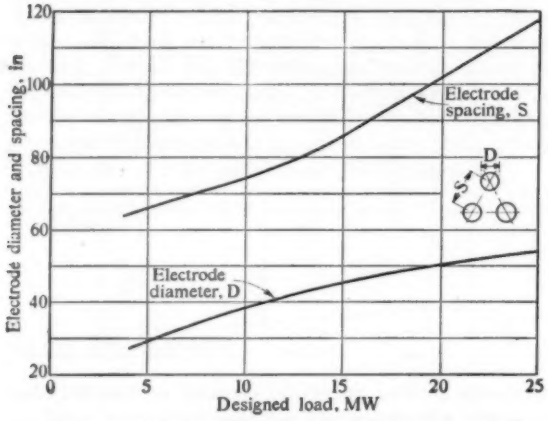
Ageing in air causes embrittlement and deterioration in the mechanical properties of most insulation. Owing to this embrittlement most machine failures are caused by a short-circuit or earth fault due to direct mechanical damage, or to electrochemical action caused by the entrance of moisture through the damaged insulation.

Calcium-Carbide Production

A DIGEST OF A UTILIZATION SECTION PAPER (No. 1721) ENTITLED "THE USE OF ELECTRICITY IN THE PRODUCTION OF CALCIUM CARBIDE," BY C. J. BEAVIS, MEMBER. THE FULL PAPER WAS PUBLISHED SEPARATELY IN OCTOBER, 1954, AND IT WAS REPUBLISHED IN APRIL, 1955, IN PART A OF THE PROCEEDINGS.

CALCIUM CARBIDE is at present the most convenient source of acetylene, which is widely used in the engineering

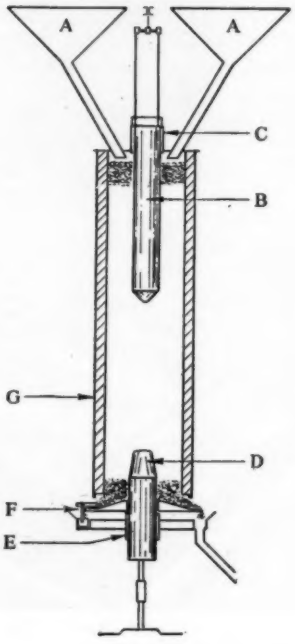
industry and is a raw material of the chemical industry. The manufacture of carbide is a smelting operation between carbon and lime at temperatures between 1 600 and 2 000°C in an electric furnace of the submerged-arc type. The modern 3-phase furnace was rapidly developed from the early ingot furnaces and its design is largely based on prior and known operating data.



1 *Electrode diameter and spacing plotted against designed load for 3-phase carbide furnaces*

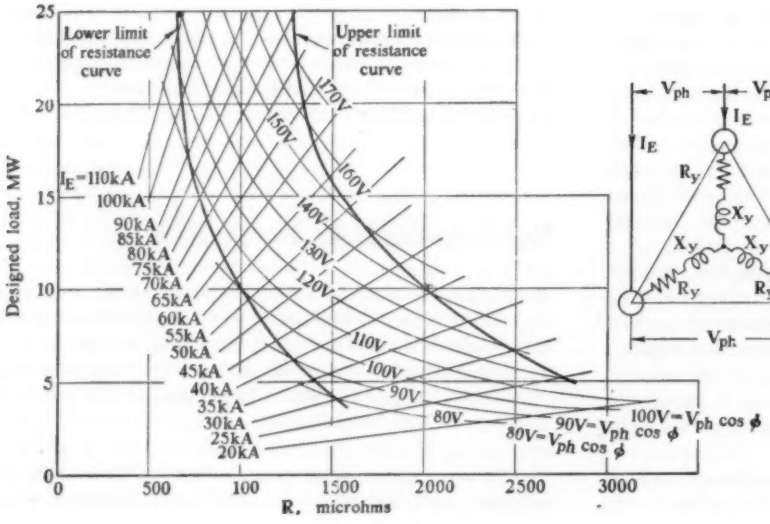
The theoretical energy rate for carbide can be calculated from a consideration of the chemical reactions involved, and is found to be about 2 800 kWh/ton, neglecting heat losses in the furnace. However, it has been established that the rate for commercial carbide, which is an 80% carbide–lime mixture, lies between 3 000 and 3 500 kWh/ton.

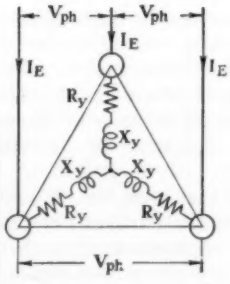
In the design of a furnace, the power input is decided by calculation from the annual carbide production, the assumed energy rate and load factor, and the total number of hours in the year. Andreae, in America, has determined two formulae from which the electrode



3 *Anthracite calcining furnace*

AA—Anthracite chutes.
B—Top electrode.
C—Electrode clamp and busbar connection.
D—Bottom electrode.
E—Electrode clamp.
F—Calcined coal extraction gear.
G—Steel shell, refractory lined.



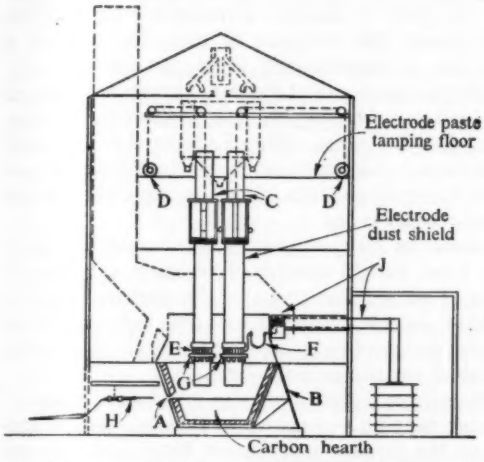


2 *Designed load plotted against charge resistance for constant electrode currents and constant electrode voltages for 3-phase carbide furnaces*

diameter, current and transformer voltage can be calculated, namely

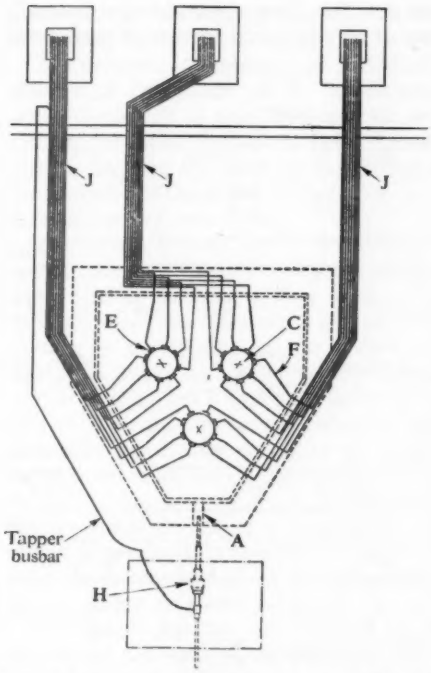
$$D^3 = b^2I^2$$
$$R\pi D = C$$

where D is the electrode diameter in inches, I is the electrode current in amperes and b is a constant calculated from the coefficient of heat transfer from the electrode to the atmosphere, the electrode temperature



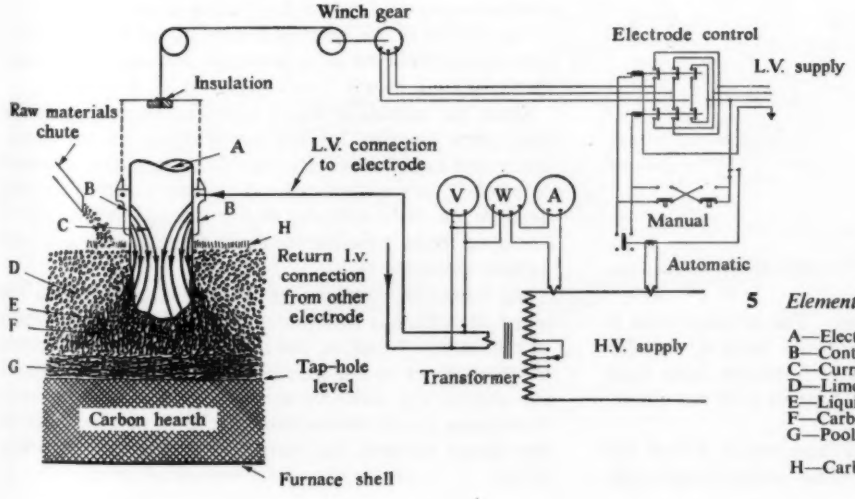
4A *Diagrammatic part elevation illustrating some features of symmetrical 3-phase carbide furnace using Soderberg electrodes*

A—Taphole.
B—"A" frames.
C—Soderberg electrodes.
D—Electrode winches.
E—Contact shoes.
F—Water-cooled conductors.
G—Clamp ring.
H—Tapping-gun assembly.
J—Interleaved busbar stack.



4B *Diagrammatic part plan of furnace shown in Fig. 4A*

A—Taphole.
C—Soderberg electrodes.
E—Contact shoes.
F—Water-cooled conductors.
H—Tapping-gun assembly.
J—Interleaved busbar stack.

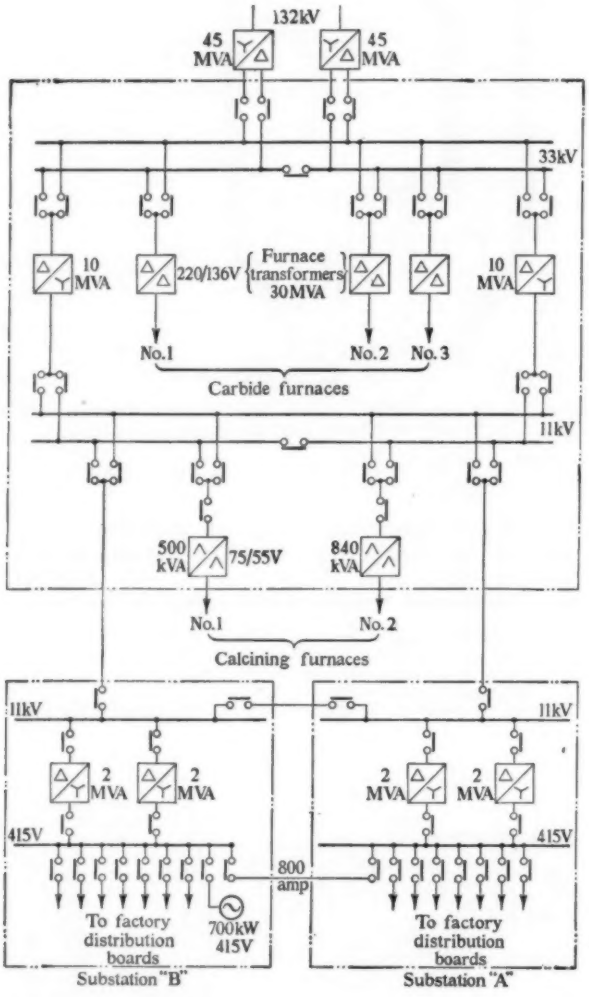


5 *Elementary diagram for carbide furnace*

A—Electrode.
B—Contact shoes.
C—Current flow.
D—Lime-coke mixture.
E—Liquid lime-gaseous coke zone.
F—Carbide formation zone.
G—Pool of liquid carbide/lime mixture (80%/20%).
H—Carbon monoxide burning to carbon dioxide.

above the charge and the resistivity of the electrode material. C is a constant called the "peripheral ohm factor."

The active area around each electrode lies within a circle of radius equal to the electrode diameter and is concentric with it. The three electrodes are generally set at the apexes of an equilateral triangle of such a size



6 ***Main power circuits***

that the active areas just overlap. The furnace bowl is then designed around the electrodes with a suitable refractory lining inside it. These formulae have been determined for various sizes of furnace and are shown graphically in Figs. 1 and 2.

The quarry, coke drying and lime plants follow the normal industrial pattern and need no further description.

The carbide furnaces are equipped with Soderberg self-baking electrodes, 48in in diameter, and the carbon paste for these is prepared from anthracite coal, calcined at the factory, and a bond made from tar and pitch. The calcining furnace is supplied by a single-phase 500kVA transformer, and is illustrated in Fig. 3.

The general arrangement of the carbide furnace is shown in Figs. 4A and 4B. Each furnace is supplied by a bank of three single-phase 10·12MVA transformers arranged for 33kV/220 volt operation as a delta/delta group. In order to maintain a reasonable power factor on the system, the reactance of these transformers is kept as low as possible and is, in fact, about 1·7%. For control of furnace load the transformers are arranged for off-load tap-changing to give a secondary voltage range of 220–136 volts. Fig. 5 shows the elementary diagram for a carbide furnace, from which it will be seen that the low-voltage delta circuit is completed at the electrode contact shoes.

To obtain an 80% carbide, the raw material in the furnace bowl should consist of 60 parts of lime and 40 parts of coke. Variations in the mixture affect the gas yield of carbide, an increase of lime reducing the gas yield. An excess of coke appears to affect the gas yield far less than variations in the lime.

The furnace is tapped at regular intervals by means of the electric tapping gun shown in Fig. 4A. This is connected to the furnace transformer bank, and when an arc is drawn between it and the "frozen" carbide at the taphole, current passes and melts the carbide, which then flows from the furnace into cast-iron moulds in which the pigs are allowed to cool before being crushed and screened into the various grades required by the market. The crushed carbide is packed into steel drums, which are made in a drum-manufacturing plant adjacent to the packing plant.

The factory derives its electricity supply from a C.E.A. substation with a direct connection on to the main Grid system. Fig. 6 illustrates the main power circuits of the factory. The Diesel generator, shown in one of the substations, is used only to keep essential services running at the factory in the event of a total power failure, and it cannot be paralleled on to the main low-voltage busbars when the bulk supply is available.

Since the carbide furnaces comprise over 95% of the load, they have by far the major effect on the power factor and load factor. By suitable design, power factors of 85–88% are maintained. The load factor obviously depends on the continuity of furnace operation, and it has been found possible to attain average monthly load factors exceeding 80%.

As mentioned earlier, the power factor at which the plant operates has been largely determined in the design of the carbide furnaces, but it can readily be appreciated that variations in the resistivity of the raw materials in the charge will have some effect on the power factor. Variations in the immersion of the three electrodes in the charge material also have their effect on the power factor.

Shaft Distortion in Steam Turbines

A DIGEST OF A SUPPLY SECTION PAPER (No. 1622) ENTITLED "SUPERVISORY EQUIPMENT FOR THE INDICATION OF SHAFT DISTORTION IN STEAM TURBINES," BY D. ANTRICH, B.SC.(ENG.), ASSOCIATE MEMBER, H. W. B. GARDINER, B.SC.(ENG.), M.I.MECH.E., MEMBER, AND R. K. HILTON, B.SC.(ENG.). THE FULL PAPER WAS PUBLISHED SEPARATELY IN APRIL, 1954, AND IT WAS REPUBLISHED IN APRIL, 1955, IN PART A OF THE PROCEEDINGS.

WITH THE INSTALLATION of larger turbo-alternators it is becoming increasingly important from an economic point of view to ensure at all times that the set is available for rapid introduction to service and continued stable running when in operation. Since one of the main reasons for non-availability is the temporary thermal distortions of the turbine rotor and casing, it was considered desirable to provide supervisory equipment which would indicate and record these.

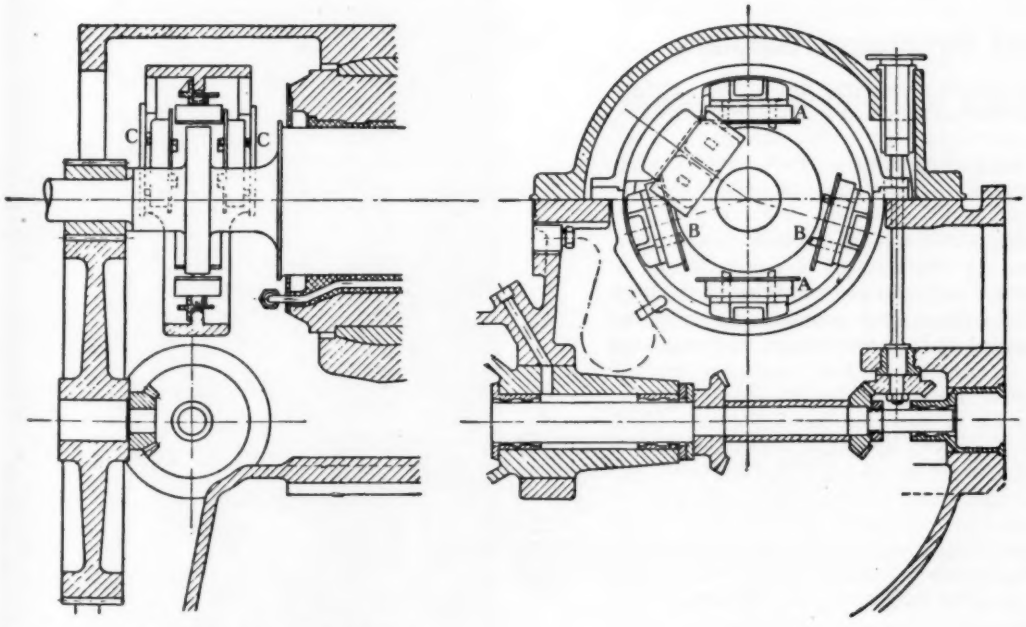
Distortions are determined by measuring the position of a steel disc fitted on the free overhung end of the turbine shaft remote from the thrust bearing in the high-pressure unit. Measurements are made by three pairs of electromagnetic detector coils placed close to the disc and rigidly fixed to the casing, as shown in Fig. 1. Relative expansion causes axial movement of the disc with respect to the bearing housing in which it runs, and any temporary distortion will cause the disc to run slightly eccentric.

The equipment is designed to have a life and reliability of the same order as the turbo-alternator. It indicates and records vertical and horizontal eccentricity of the disc and its differential axial movement with respect to the casing. In addition, the equipment indicates the mean position of the disc on the shaft journal with respect to the bearing and its oil film in both vertical and horizontal directions.

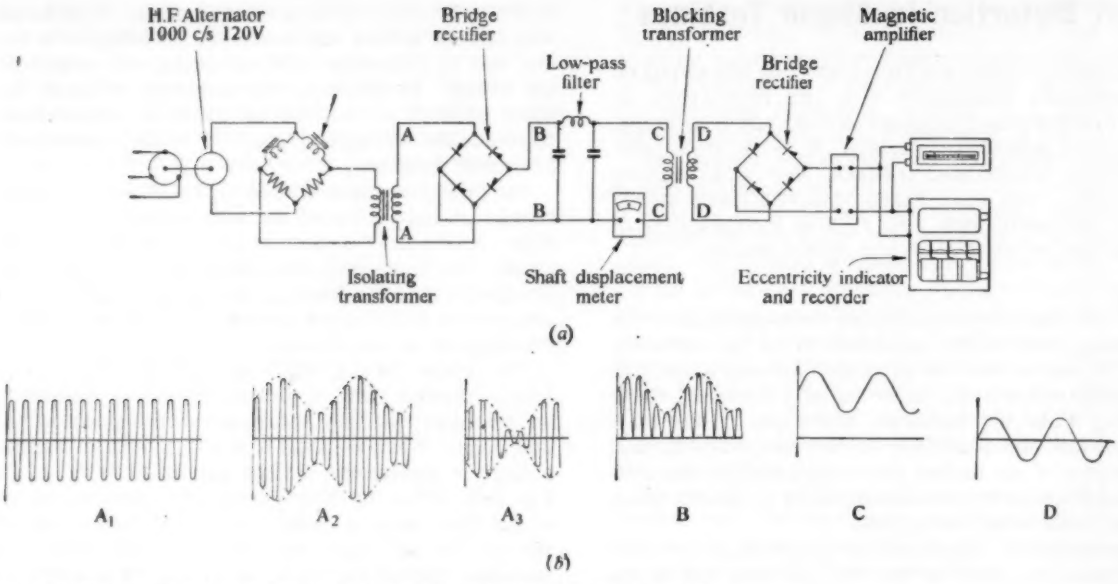
The principle of measurement is that of the differential change of impedance of the electromagnetic detector coils. Each pair of coils form opposite arms of a bridge circuit, the other two arms being resistors. Identical circuits are used for detecting the vertical and horizontal components of the radial motion; Fig. 2 shows a simplified diagram of one of them.

The bridge circuits, which are energized by a 1 kc/s supply derived from a permanent-magnet generator, are biased so that they always work on one side of the null point. When the shaft is at rest, the out-of-balance voltage is represented by the carrier wave at A_1 in Fig. 2(*b*). When the shaft is in motion, eccentric rotation of the disc causes a cyclic variation of the air-gaps of the vertical and horizontal detector coils, which will modulate the carrier wave, as at A_2. The depth of modulation is directly proportional to the eccentricity. A shift of the mean position of the shaft will alter the mean value of the carrier wave, as at A_3. The succeeding circuit is arranged to separate the depth of modulation from the mean value of the bridge output, and these two quantities are indicated separately.

The circuit for the measurement of differential expansion of the shaft is similar to the part of the circuit for eccentricity measurement up to the point where the



1 *Position of the detector coils on the turbine*



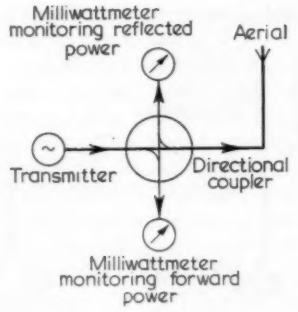
2 *Circuit showing the basic principle of detection of eccentricity of the shaft*
(*a*) Simplified circuit diagram. (*b*) Waveforms at various points.

d.c. component is extracted to indicate shaft displacement. Speed is also measured and recorded, so that shaft distortions may be correlated for subsequent analysis of the performance of the machine. Four 60 MW turbo-alternators have been fitted with supervisory equipment and have been operating for some time.

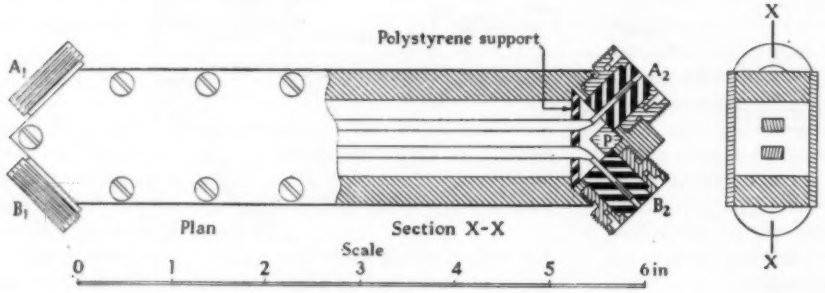
Symmetrical Directional Couplers

A DIGEST OF A RADIO SECTION PAPER (No. 1833 R) ENTITLED "COUPLED TRANSMISSION LINES AS SYMMETRICAL DIRECTIONAL COUPLERS," BY G. D. MONTEATH, B.SC., ASSOCIATE MEMBER. THE FULL PAPER WAS PUBLISHED IN MAY, 1955, IN PART B OF THE PROCEEDINGS.

THE PRIMARY OBJECT of the work described in the paper was to facilitate the measurement of power flowing in transmission lines at radio frequencies between 100 Mc/s and 1 000 Mc/s. Current and potential difference are not easily measured at high frequencies, and it is even more difficult to determine the phase difference between these quantities. It is therefore preferable to measure the amplitudes of the waves travelling forwards and backwards along the line, so that the net transfer of power is determined as the difference between the powers

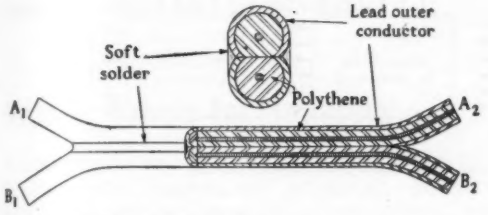


1 *Method of monitoring power supplied to an aerial*



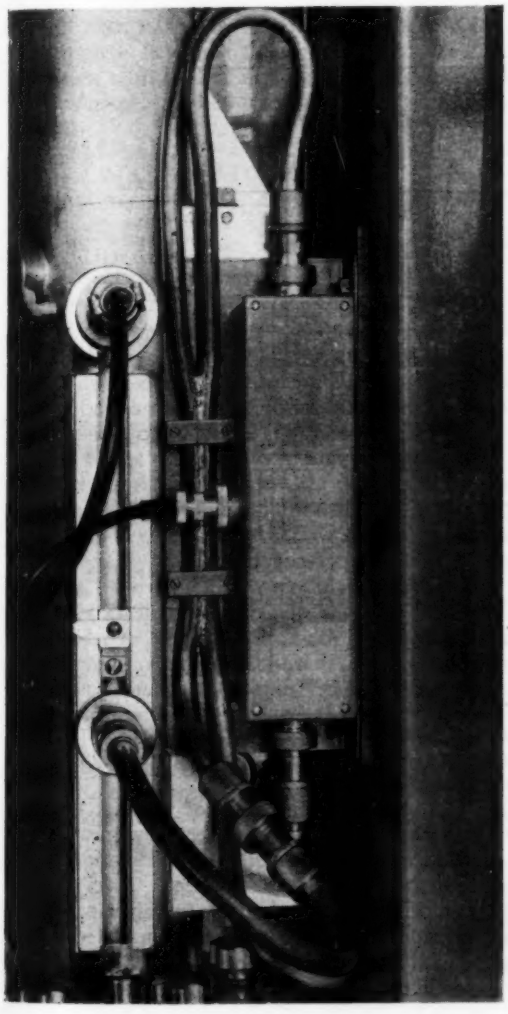
2 *Directional coupler for laboratory use*

flowing in the two directions. In order to carry out measurements in this way a directional coupler is required, i.e. a device inserted in a transmission line and giving two subsidiary outputs, each proportional to the amplitude of the waves travelling in one direction only.



3 *Simple directional coupler*

4 *Power monitor in u.h.f. transmitter*



Its use for monitoring the power supplied to an aerial is illustrated in Fig. 1; this arrangement enables the reflection coefficient at the aerial to be determined at the same time. If the aerial is initially matched to the transmission line, any change in its impedance—e.g. as a result of ice formation—is made apparent by an indication of reflected power.

The paper describes a particular type of symmetrical directional coupler in which two unbalanced transmission lines are coupled by sharing a common outer conductor for part of their length, so as to form a three-conductor line. The strength of the coupling, i.e. the power delivered to the appropriate subsidiary output for a given power flowing in the main transmission line, depends on the cross-section of the three-conductor line, and on its length, being greatest when the length is one quarter-wavelength.

Fig. 2 shows a directional coupler designed to form part of laboratory power-measuring equipment for frequencies between 100 Mc/s and 1 000 Mc/s. The simpler type shown in Fig. 3, which can be made in a few minutes by grafting two lead-covered coaxial cables together, was developed for monitoring transmitter power. Fig. 4 shows a typical installation in a transmitter used in long-range propagation experiments. One of the cables replaces an existing link between the output of the final amplifier and the aerial terminal; the ends of the other cable are connected to matched crystal detectors in the box on the right of the photograph.

Although the work described in the paper had the measurement of power as its principal object, other applications of the directional couplers are suggested. These include all-pass or constant-resistance networks, and applications to phase-rotation aerial systems.

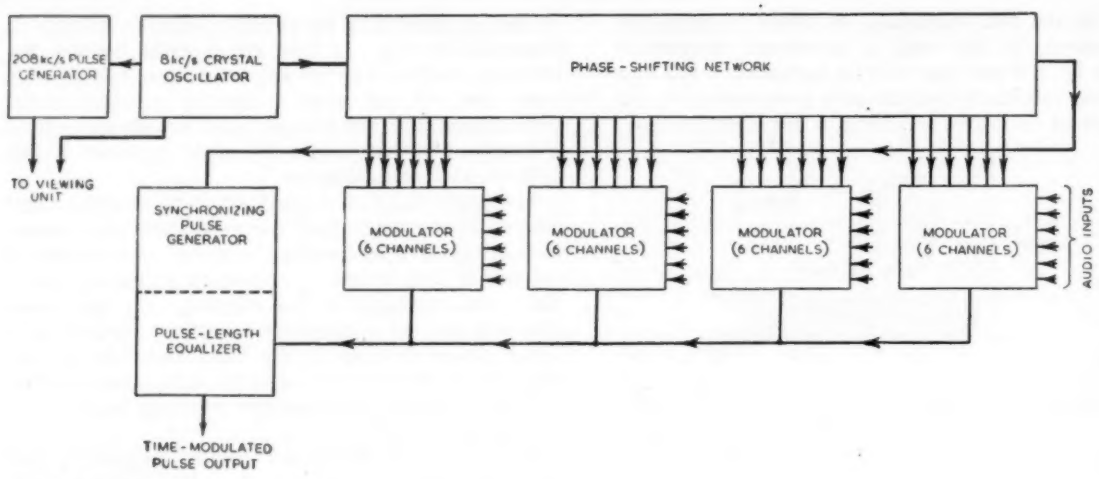
Pulse-Time-Modulation Equipment

A DIGEST OF A RADIO SECTION PAPER (No. 1812) ENTITLED "A 24-CHANNEL PULSE-TIME MODULATION SYSTEM," BY R. F. B. SPEED, B.A. THE FULL PAPER WAS PUBLISHED IN MAY, 1955, IN PART B OF THE PROCEEDINGS.

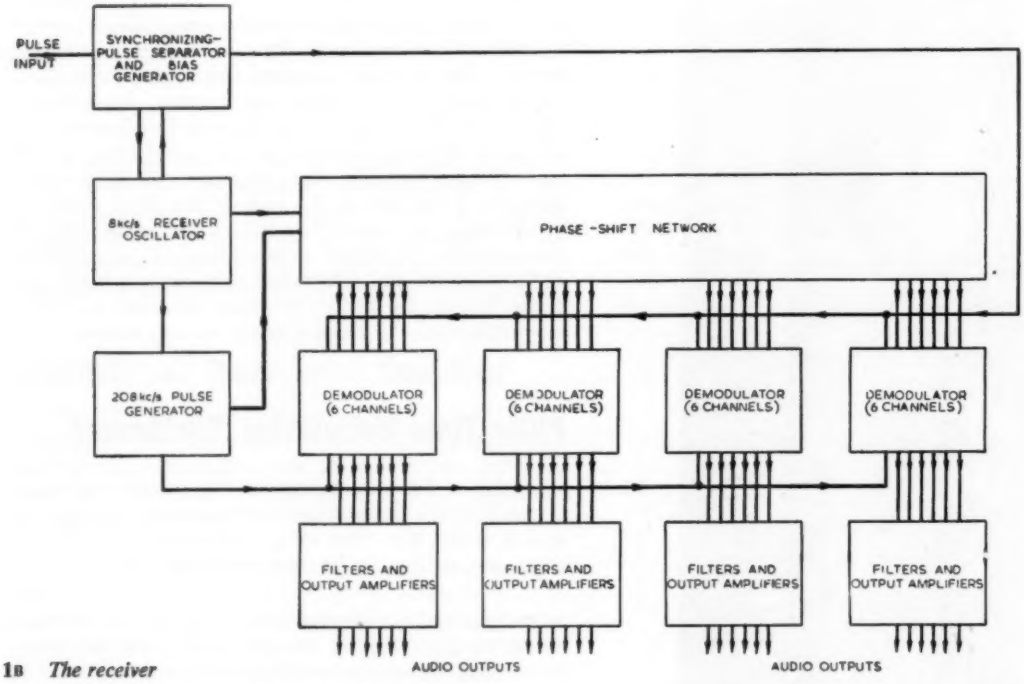
ALTHOUGH THE USE of time division for the multiplexing of signals dates back to the last century, its possibilities in relation to speech transmission have come to be realized only during the last 20 years.

In multiplex systems using the familiar frequency division each channel uses part of the available bandwidth all the time, while for time division each channel uses all of the bandwidth for part of the time.

The general layout of the pulse equipment is illustrated by the block diagrams of Fig. 1: twenty-four channels are combined by interlacing 24 pulse trains each with a pulse repetition frequency of 8 kc/s. The pulses of each pulse train are modulated about their mean positions by one of the incoming speech signals. In addition a double synchronizing pulse is added to the combined pulse train



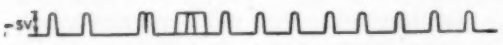
1A *The transmitter*



1B *The receiver*

so that the receiver may be phase-locked to the incoming signal. The resultant combined pulse train is illustrated in Fig. 2. This pulse signal is used to frequency-modulate an r.f. carrier.

The pulse output from the radio receiver is fed to the pulse demodulation equipment, which is synchronized by a method analogous to the "flywheel sync" used in some television receivers. The use of this, as opposed to more normal types of synchronization, gives a signal/noise improvement of 3 dB.



2 *Output pulse train*

In the modulators use is made of the fact that the steepest portion of a sine wave is effectively linear. This linear portion is compared with the modulating signal to produce time-modulated pulses direct. A very simple network comprised of cascaded low (or high)-pass filter sections provides an 8 kc/s sine wave in the different phases required for the modulators.

As a result of using a simple distributor and also

economical modulation and demodulation circuits, the number of valves in the pulse equipment is kept down to 4·5 per one-way channel.

The performance of the pulse equipment, together with that of the radio equipment is, in every way, as good as or better than that recommended by the C.C.I.F. for long telephone circuits over coaxial cables.

Better Valves for Industry

A DIGEST OF A RADIO SECTION PAPER (No. 1740) ENTITLED "THERMIONIC VALVES OF IMPROVED QUALITY FOR GOVERNMENT AND INDUSTRIAL PURPOSES," BY E. G. ROWE, M.SC., MEMBER, P. WELCH AND W. W. WRIGHT, B.SC. THE FULL PAPER WAS PUBLISHED SEPARATELY IN JANUARY, 1955, AND IT WAS REPUBLISHED IN MAY, 1955, IN PART B OF THE PROCEEDINGS.

ELECTRONICS HAS GROWN RAPIDLY in the past ten years. This growth has been due, not only to the expanding television market, but also to increased industrial and Service usage. Table 1 shows typical failure rates of

Table 1

	%
Valves	64·0
Resistors	8·8
Condensers	7·2
Wiring errors	6·2
Dry rectifiers	4·5
Mechanical items	2·4
Miscellaneous	6·9

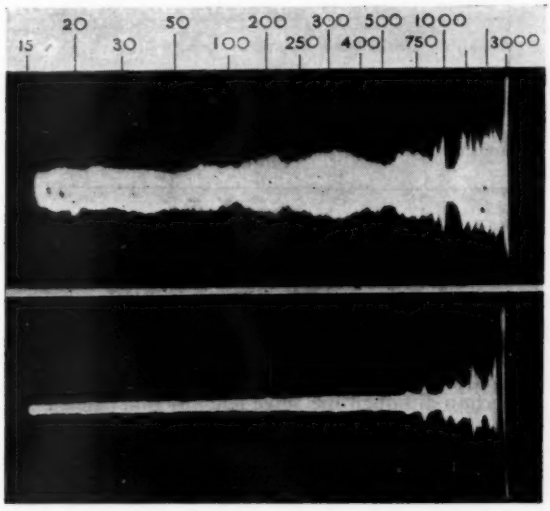
components in the latter equipments, and emphasizes the need for a valve which is more reliable than the conventional domestic radio valve, a need which has led during the past six years to an intensive programme of development on valves of improved quality.

Such valves can fall into several classes, but the major emphasis in the paper is placed on valves with normal lives under moderate conditions of vibration and shock, as would be met in aircraft, mobile equipment, etc. Other aspects, such as long lives and greater characteristic stability, have come out of the main effort, rather in the nature of ancillary improvements.

In order to study the effects of vibration on the projected range of valves it was necessary to evolve new systems of mechanical testing. After much experimental work on mechanical shake tables, the difficulties in correlating results, together with the need to test at high vibration frequencies, made the purely mechanical system rather difficult, and thus electromagnetic transducers were introduced. With such equipments it was possible to carry out studies on the behaviour of normal commercial receiving valves and a pattern of the failure performance was deduced.

Attention was then directed at the laboratory design of the reliable valve, and from fatigue experiments it was apparent that one of the major faults in the valve was evolution of gas, notably from abrading of the mica insulator, which caused early emission failure. It was realized that, if the valve design is such that relative movement of mica and component is eliminated, no abrading can occur. This was achieved by the careful locking of all the valve components into the micas, together with rigid connection between the lower mica and the valve stem.

One of the main improvements in the electrical field has been the significant reduction in noise and microphony which has resulted from the mechanical strengthening described, together with marked improvements in stability (Figs. 1 and 2).

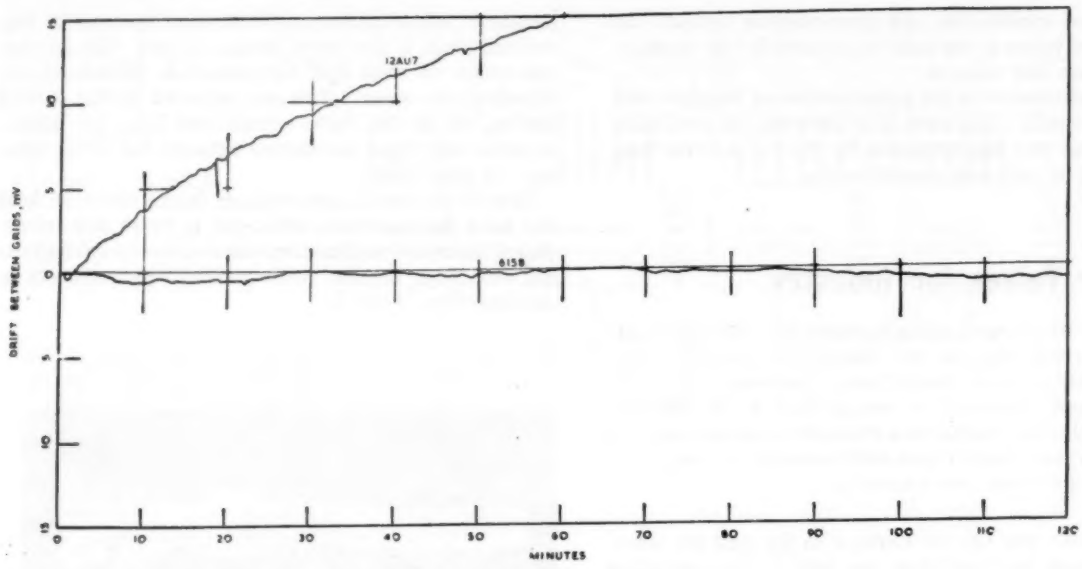


1 *Comparison of the noise spectrum existing on the normal valve and that on the reliable version, demonstrating the big improvement achieved*

Valves are mounted in glass envelopes, and their manufacture involves extensive glass-working operations which in the main have derived from lamp-work practice. A careful scientific study of the stress distributions in the base, bulb and seal-off tip of the all-glass valve has led to control methods based on thermal shock tests being applied to the factory processes.

It is not enough to design reliability into a radio valve; if the finished article is to be of ultimate value to the user, it must be capable of being manufactured under mass-production methods. This has resolved itself into a control of the basic materials, the processes and the operator variability.

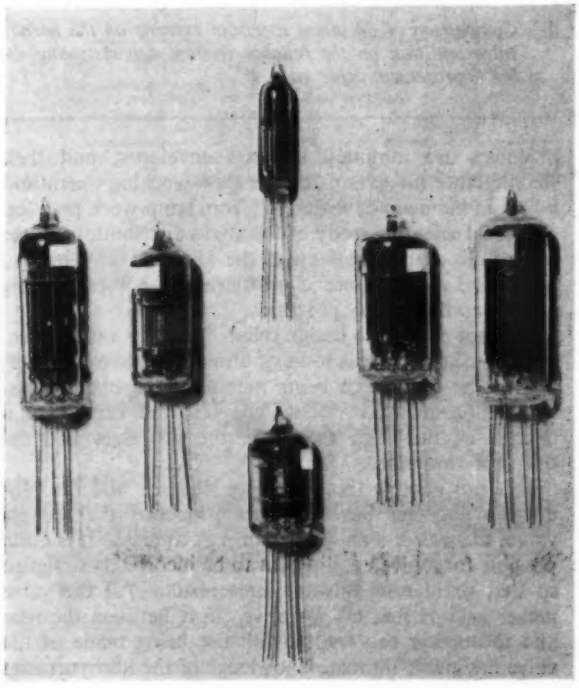
It is not enough that the valve designer and the production engineer have together produced the reliable valve; the user has an important part to play. It is quite possible for a given equipment to be incorrectly designed so that premature valve failures result. All the valve maker asks is that co-operative effort between the user and the maker can lead to full use being made of the valve designer's intimate knowledge of the idiosyncrasies



2 *Typical 2-hour stability curves for valves of types 6158 and 12AU7*

of the valves. The equipment manufacturer can also help; the proper use of wiring jigs and pin-straighteners has done much to improve the apparent poor performance of certain valves, for often the damage is done on insertion although the valve actually fails later.

3 *Typical wire-ended valves for modern equipment practice*



Already the results of the field experience on the existing valve types are showing that increased life, stability of performance and freedom from random noises are natural outcomes from their use. The "wired in" valve (Fig. 3), which is a natural and logical development from the reliable valve, is opening up a new field in circuit stability. A new technique of circuit design is growing up around these valves, and although a valve should not be used if a mechanical device will perform the function more efficiently, in the many cases where the valve must be used, the reliable valve as we know it to-day can be relied upon to perform its desired task efficiently and without failure.

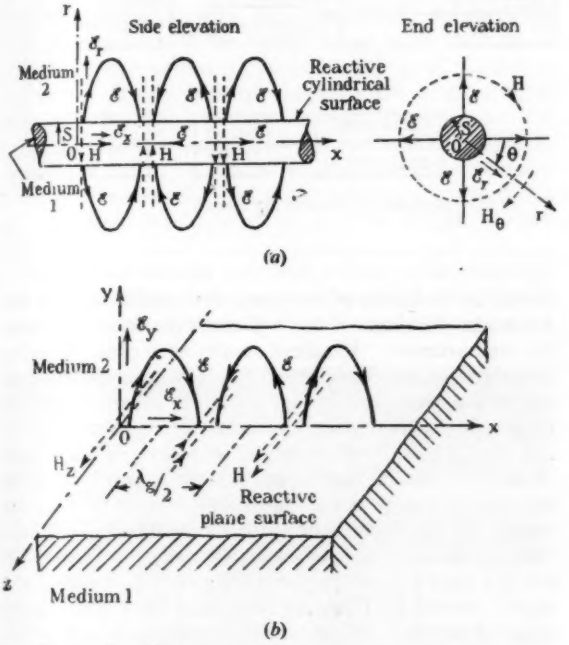
For the future we can look forward to an era when the valve can be used more widely in modern industrial equipment and where "fit and forget" can be the keynote of the valve user.

Axial Cylindrical Waves on Capacitive Surfaces

A DIGEST OF A RADIO SECTION PAPER (No. 1786) ENTITLED "AN EXPERIMENTAL INVESTIGATION OF AXIAL CYLINDRICAL SURFACE WAVES SUPPORTED BY CAPACITIVE SURFACES," BY PROFESSOR H. E. M. BARLOW, PH.D., B.SC.(ENG.), MEMBER, AND A. E. KARBOWIAK, PH.D. THE FULL PAPER WAS PUBLISHED IN MAY, 1955, IN PART B OF THE PROCEEDINGS.

THE SINGLE-WIRE TRANSMISSION LINE supporting a cylindrical surface wave is well known [Fig. 1 (*a*)]. Such waves, in travelling along the outside of a conductor of circular cross-section, do not radiate, so that, neglecting

losses in the guide, the energy is propagated exclusively along its surface. The Zenneck wave [Fig. 1(*b*)], which behaves in a similar way over a flat surface, has been put forward as a particular case of the cylindrical surface wave when the guide is of infinite radius. There is, however, one important distinguishing characteristic between the usual forms of these waves. Thus the cylindrical surface wave has always been characterized by a phase velocity which is less than the free-space value,



1 *Forms of surface wave*

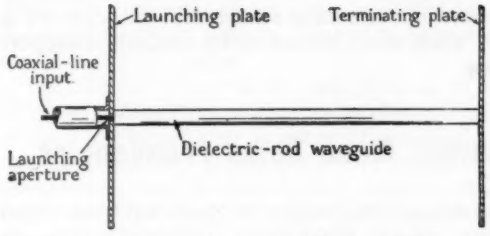
(*a*) Axial cylindrical surface wave (single-wire transmission line).
(*b*) Zenneck wave (inhomogeneous plane wave).

whereas the Zenneck wave exhibits a phase velocity exceeding that value.

Owing to experimental difficulties the problem of following the transitional changes from one form of this surface wave to the other has so far not been satisfactorily resolved, and the difference between the phase velocities has tended to suggest that there is perhaps something of basic importance in its explanation.

In a recent paper* it was shown theoretically that an axial cylindrical surface wave should be capable of support by a guide having a capacitive surface impedance within defined limits, and that in those circumstances the phase velocity of the wave along the interface with the surrounding medium should exceed the corresponding free-space value. Previously it had been supposed that only guides with a positive surface reactance were capable of providing the service required, and the present work was undertaken in order to ascertain experimentally the threshold conditions for the support of such waves, which are apparently more closely akin to the Zenneck wave.

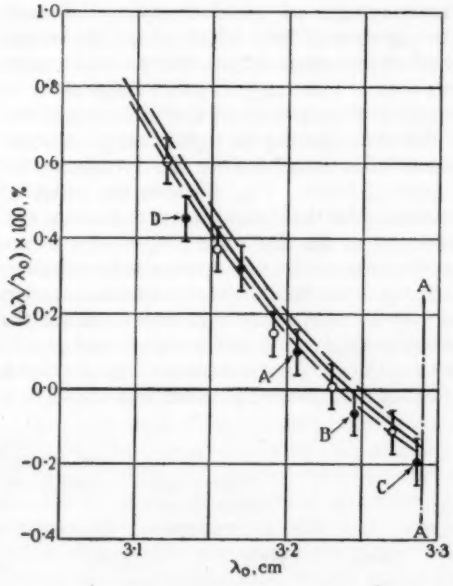
In pursuing this objective a solid dielectric rod, made of Perspex, was used as the guide, and its diameter was carefully adjusted to make the surface impedance come within the particular range of interest. The guide was mounted in the surface-wave resonator (Fig. 2) which



2 *Surface-wave resonator with dielectric-rod waveguide*

had been used in the previous experiments on dielectric-coated and corrugated wires, so that the technique of measurement was well established.

The experiments show that there is no doubt at all about the physical reality of an axial cylindrical surface wave supported by a capacitive surface and having a phase velocity *exceeding* that of light. Moreover, it was established that, within the limits of experimental error,



3 *Calculated and measured values of the percentage decrease in wavelength along guide No. 2 in relation to the free-space wavelength*

Guide radius = 0·9781(5) cm.
● Experimental points for guide length of 116·90 cm.
○ Experimental points for guide length of 116·28 cm.

* Barlow, H. E. M., and Cullen, A. L.: "Surface Waves," *Proceedings I.E.E.*, Paper No. 1482 R, November, 1953 (100, Pt. III, p. 329).

such waves vanish completely when the threshold condition necessary for their support in the capacitive region is approached, exactly as predicted by theory.

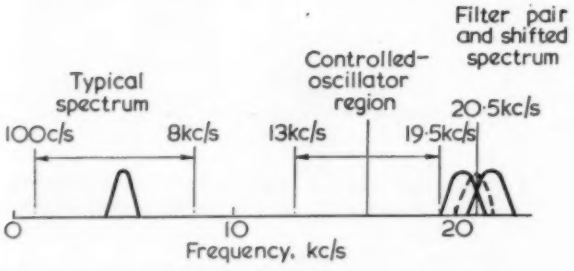
Fig. 3 summarizes the results obtained, showing both calculated and measured values of the percentage decrease in wavelength along the guide in relation to the free-space wavelength. Thus, as the curve crosses the horizontal axis, the phase velocity of the wave becomes greater than the velocity of light, but the field continues to maintain its characteristics as a surface wave until the point AA is reached, when those characteristics suddenly disappear altogether.

Measuring Mean Noise Frequencies

A DIGEST OF A MEASUREMENTS SECTION PAPER (No. 1836 M) ENTITLED "MEAN FREQUENCY DETERMINATION OF NARROW-BAND NOISE SPECTRA," BY W. W. H. CLARKE, PH.D., B.SC., ASSOCIATE MEMBER, AND R. F. NIKKEL, M.A.SC., B.A.SC. THE FULL PAPER WAS PUBLISHED IN MAY, 1955, IN PART B OF THE PROCEEDINGS.

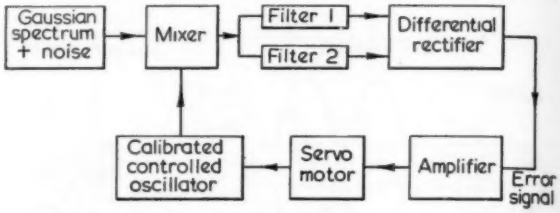
THERE ARE A NUMBER OF PROBLEMS involving the measurement of signals which are composed neither of sine waves nor of random noise, but which have some of the characteristics of each. A symmetrical Gaussian energy/frequency distribution whose width is proportional to its mean frequency falls in this category, and the paper describes theoretical and experimental work on the automatic measurement of mean frequency of such spectra in the presence of level white noise. By means of the method described it is possible to make such measurements over a wide range of mean frequencies.

The assumption of symmetry of the signal spectrum suggests the idea of comparing the signal energy on either side of a chosen "trial value" for the mean frequency by means of a pair of filters. Fig. 1 shows the range of frequencies occupied by the signal spectra and noise, and how their addition to the sine-wave output of a servo-controlled oscillator produces new spectra at the addition frequency. The pair of filters whose responses overlap at a frequency of 20·5 kc/s is of optimum form for the range of spectra, utilizing maximum signal energy and giving good signal/noise discrimination. Fig. 2 gives a block schematic of the measuring circuit, and shows how the mean frequency of the signal spectrum can be monitored continuously.



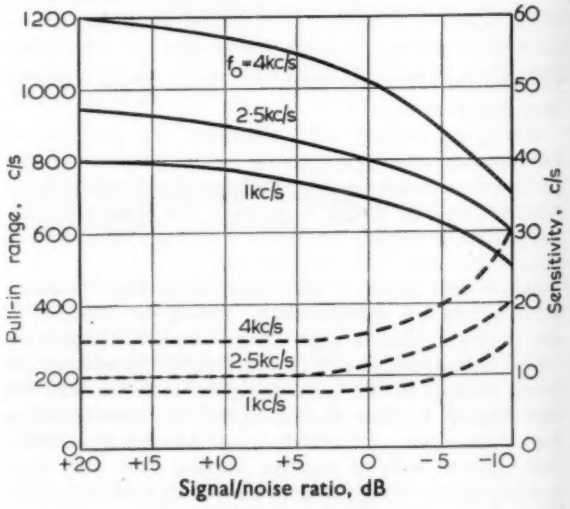
1 *Frequency scale of measuring process*

Factors which influence the choice of filter bandwidth are the required pull-in range and the loss of sensitivity owing to the presence of excessive noise. Pull-in range is the maximum frequency deviation of the oscillator from the condition of balance from which it will pull in steadily towards balance. Sensitivity is the minimum



2 *Block schematic of measuring circuit*

frequency deviation of the controlled oscillator from the condition of balance which will cause the servo to correct the measurement. Excellent results were obtained using filters whose responses were 750 c/s wide at points 6 dB below the pass level. Fig. 3 shows values of pull-in range and sensitivity for mean signal frequencies f_0 of 1, 2·5 and 4 kc/s, with signal/noise ratios varying from + 20 to − 10 dB. Signal/noise ratio is here defined as the ratio of energy in the Gaussian spectrum to the noise energy in the total bandwidth from 100 c/s to 8 kc/s. The maximum errors of mean frequency measurement are less than 1% of the mean frequency f_0, except for a signal centred at 1 kc/s accompanied by a signal/noise ratio of about − 10 dB, when the maximum error approaches 1·5% of f_0.



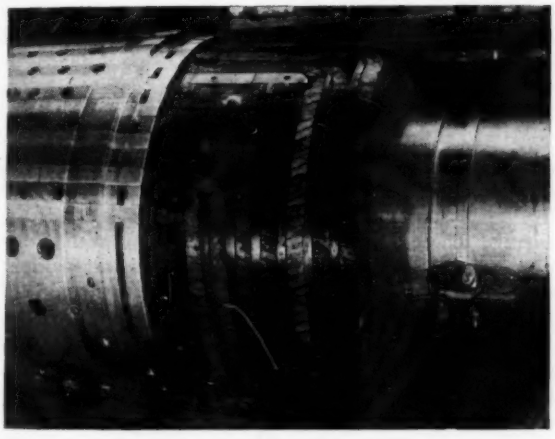
3 *Pull-in range and sensitivity as functions of signal/noise ratio*
——— Pull-in range. — — — — Sensitivity.

Distortion of Turbo-Alternator Rotor Windings

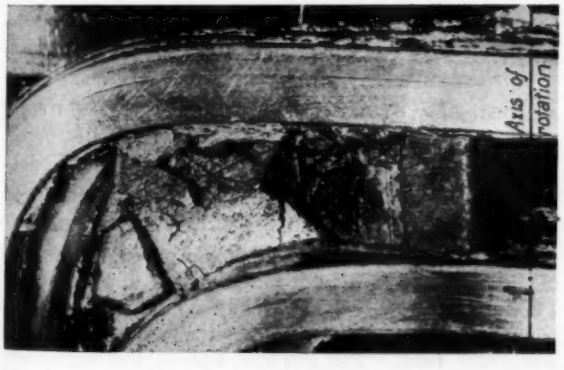
A DIGEST OF A SUPPLY SECTION PAPER (NO. 1813) ENTITLED "DISTORTION OF TURBO-ALTERNATOR ROTOR WINDINGS THROUGH THERMAL STRESS," BY D. B. REAY, M.SC.(ENG.), MEMBER. THE FULL PAPER WAS PUBLISHED IN JUNE, 1955, IN PART A OF THE PROCEEDINGS.

THE PAPER DEALS with the assessment of operating temperature limits for turbo-alternator rotor windings of cold-worked silver-bearing copper. The particular aspect considered is the rate of copper shortening in these windings through thermal stress. Because of the influence of rotor diameter on stator size, it is important, with large units, to know whether copper-shortening rates, or, alternatively, insulation characteristics determine the maximum safe loading for a given design of rotor winding.

Widespread trouble occurred in the nineteen-thirties and -forties from open-circuiting or short-circuiting of end turns of rotor windings of ordinary copper through



1 *Rotor winding in new condition*



2 *Displaced end turns and crushed packing blocks*

relative movement of the turns. Fig. 1 shows a newly-completed winding without the retaining ring, and Fig. 2 illustrates relative displacement of end turns and the accompanying disintegration of packings in service.

These movements result from shortening of certain of the slot winding strips. The winding on heating tends to expand axially in relation to the rotor body, the winding being hotter than the body and also having a higher expansion coefficient. The machine being on speed, the expansion of the strips is resisted by friction through centrifugal pressure between turns and between top turn and slot wedge.

The friction forces on the end portions of the slot strips may, depending on the length, diameter and speed of the rotor, be sufficient to prevent the expansion of the mid-length sections relative to the rotor body. If the temperature strain in these locked portions exceeds the elastic limit of the copper, super-elastic deformation will occur.

When the machine is shut down and cools, the turns assume a free length slightly less than their previous length. The process is repeated at each operating cycle, the cumulative effect being accentuated by frequent starting and stopping.

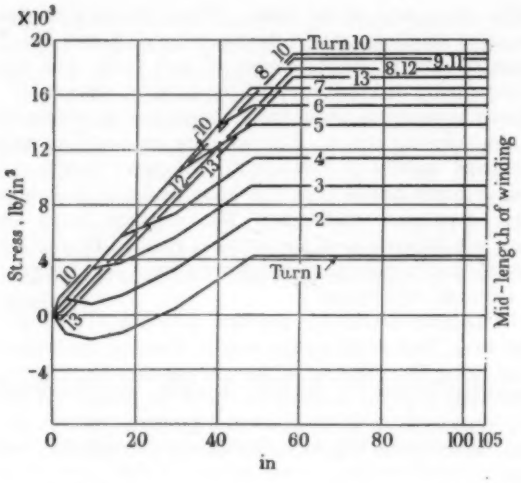
A further factor in the mechanism of copper shortening is creep deformation, which in ordinary copper can be very considerable at operating temperatures in combination with the corresponding stresses. Some severely distorted windings have in fact shown no indication of hardening in service such as would accompany super-elastic strain. In these windings the deformation was presumably due wholly to creep strain, the hardness of the windings generally corresponding to an elastic strength somewhat above the estimated maximum working stress.

Partly hardened ordinary copper was used at an early stage in combating deformation, but was abandoned because of its rapid softening and high creep rate even at operating temperatures.

A solution to the problem was found in the use of 10% cold-worked 0·1% silver-bearing copper, which has the necessary elastic strength and resistance to resoftening, and comparatively high resistance to creep. Much additional quantitative information on this material has latterly become available, and is applied in the paper in estimating deformation rates for a large rotor winding at given temperatures and resulting stresses.

The coefficients of friction used in the stress evaluations are based on observations of the starting points of increase in hardness in service (and therefore of stress to the elastic limit) in discarded windings of ordinary copper. The analysis indicates that, contrary to an earlier theory, the minimum assignable value of the friction coefficient between the slot wedge and the top turn ($\mu_{w.1}$) is not much smaller than that between turns (μ_t).

Fig. 3 shows the stress distribution in a 13-turn stack in which there is a temperature gradient from 86°C at the top turn to 140°C at the hottest turn (No. 10 down)

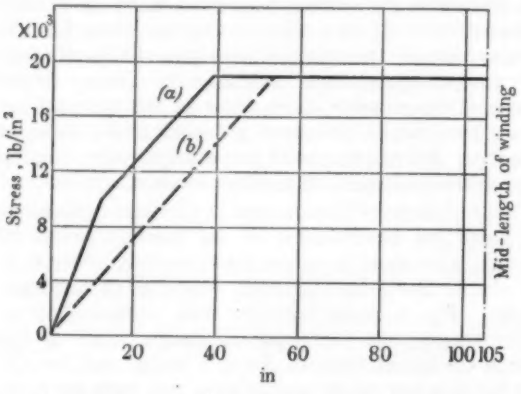


3 *Stress distribution in slot strips of 13-turn stack with a given temperature distribution*
$\mu_{w\cdot i} = 0{\cdot}20$; $\mu_t = 0{\cdot}25$.

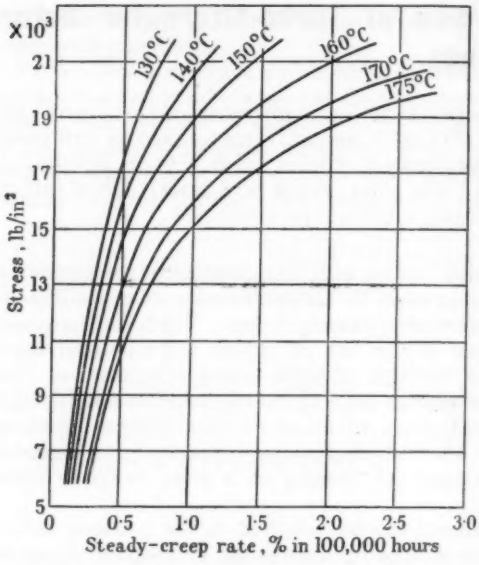
and thereafter to 134°C at the bottom turn. This temperature pattern is broadly representative of operating conditions in the nineteen-thirties and explains why maximum shortening occurred in those turns near the bottom of the slot.

The paper indicates to what extent a falling temperature gradient towards the bottom turn results in a more severe condition in the hottest turn for a given temperature than when the temperature is uniform from the hottest turn to the bottom of the stack (see Fig. 4).

Fig. 5 shows curves of steady-creep strain rates for partly-hardened 0·1% silver-bearing copper, deduced from published test results. Initial creep, being non-recurrent, is shown to be of minor importance.



4 *Stress distribution in slot strip No. 6 (down) of 13-turn stack*
(*a*) When No. 6 turn is at 140°C, and with a temperature gradient falling to 88°C at bottom of stack.
(*b*) When turns 6 to 13 are all at 140°C.



5 *Steady-creep strain rates for 10–50% cold-worked on 0·1% silver-bearing copper*

It is concluded that, to avoid excessive deformation in large windings of cold-worked silver-bearing copper in, say, 100 000 hours' aggregate operation, the temperature rise in the hottest turns, and not merely the average rise, should be limited to the average temperature rise given in B.S. 225. Unfortunately resistance readings give the average temperature rise, and the temperature distribution in conduction-cooled windings is a complex question; suggestions are therefore made for indicating and controlling zone temperatures in such windings.

The author also concludes that, by reason of the low rate of creep strain, and consequently of stress relaxation, in windings of cold-worked silver-bearing copper, two-shift operation with this material is not appreciably more conducive to deformation than weekly or even longer operating cycles.

Waveguide Techniques

A DIGEST OF A STUDENTS' PAPER WITH THE ABOVE TITLE, BY M. H. ALDER, B.SC.(ENG.), GRADUATE. THE PAPER WAS AWARDED A STUDENTS' PREMIUM BY THE COUNCIL, AND A LONG ABSTRACT OF IT WAS PUBLISHED IN THE STUDENTS' QUARTERLY JOURNAL, MARCH, 1955.

WAVEGUIDES ARE USED to support and propagate electromagnetic waves in a frequency band of approximately 1 000–30 000 Mc/s. They usually consist of tubes of rectangular cross-section, but a circular cross-section is sometimes used. The physical size of the waveguide determines the lower frequency limit of the energy it will

transmit. The two outstanding advantages of waveguide over coaxial propagation are the small transmission loss and the large power-handling capacity.

Form of the Wave in the Guide

The basis of the guided wave is an electromagnetic field, and the energy of the field is stored in the space inside the guide. The penetration of the field into the waveguide walls is only a few microns in depth. The rectangular guide may be built up simply from a parallel two-wire transmission-line system. If a number of $\lambda/4$ short-circuited lines are connected to a transmission line at right-angles, they will not affect the performance. If the number becomes infinite, the structure becomes solid and the result is the rectangular waveguide.

The H_{01} mode is the most common in rectangular guides. The wavelength of the guided wave is longer than the free-space wavelength and is given by

$$\frac{1}{\lambda_g^2} = \frac{1}{\lambda_0^2} - \frac{1}{\lambda_c^2}$$

where λ_g = Guide wavelength.
λ_0 = Free-space wavelength.
λ_c = Cut-off wavelength.

For the H_{01} wave in a rectangular guide, $\lambda_c = 2b$, where b is the longer dimension of the guide cross-section.

Currents and potential differences do not exist in waveguides as unique quantities, and the conventional idea of impedance must be replaced by one of normalized impedance. This is the ratio of the wave impedance at a given plane to the characteristic impedance of the guide. The aim in most waveguide transmission systems is to produce a normalized impedance of $1 + j0$ at all points, i.e. a matched system with no reflected waves.

Typical Microwave Test Bench

Much of the design work of microwave systems is performed at low power levels on a suitable test bench.

The essential components of any microwave test bench are

An oscillator.
A frequency-meter.
An attenuator.
A standing-wave indicator.

Various other components, such as crystal detectors, matched loads and directional couplers, are also used.

The oscillator, which is the source of the microwave energy, is usually a reflex klystron. This type of valve is convenient to operate and tunes over a fairly wide range of frequencies. Methods of frequency determination by wavelength measurement are generally inconvenient. The most useful type of wavemeter is the resonant cavity. Its main disadvantage is the spurious responses that may be obtained, but these can be avoided by good design. The dissipative waveguide attenuator is used for power-level adjustment and for the measurement of attenuation by substitution. The principal measuring instrument of the microwave test bench is the standing-wave indicator. It will measure the standing-wave ratio in the waveguide system and can be used to determine the impedance at any given plane.

Impedance Matching

To achieve an impedance match it is necessary to measure the degree of mismatch produced by the particular waveguide component concerned. If the voltage standing-wave ratio and the position of a voltage minimum are known from a standing-wave-indicator measurement, the normalized impedance or admittance can be calculated with the aid of a Smith circle diagram. With a knowledge of the normalized impedance, the value and position of a parallel impedance can be calculated such that the whole system becomes matched.

Power Measurement

Most methods of microwave power measurement involve the conversion of this power into heat. At high power levels—above about 10 watts—flow-calorimeter methods are used. The power is absorbed in a hollow wedge-shaped load mounted inside the waveguide, and a flow of water circulates through the wedge. The problem is now one of measuring the rate of flow and the temperature rise of the water. At low levels, thermally-sensitive devices such as thermistors and bolometers are employed. The bead type of thermistor has a very steep negative resistance/temperature coefficient, and is especially useful at the shorter wavelengths owing to the extremely small size of the bead. The thermistor is mounted across the waveguide, and a good match is obtained by means of short-circuiting plungers. It is common practice to connect the thermistor as one arm of a Wheatstone-bridge circuit, which is balanced when there is no microwave energy. The power measurement is performed by substituting in the thermistor an amount of d.c. power to produce the same bridge unbalance as the microwave power.

Radar Circuit Design

To give a wider illustration of waveguide techniques, the paper contains a brief description of a complete microwave radar system. The practical problems of switching microwave energy at high power level, the internal air-conditioning of the waveguide system and the use of flexible waveguides for shock absorption are dealt with. The circuit of an automatic-frequency-control system is described whereby the local oscillator is adjusted so that a constant intermediate frequency is obtained.

Future Possibilities

To combat the relatively high cost and close mechanical tolerances demanded of present waveguide transmission systems, a large amount of development work is being carried out to produce alternatives. Practical difficulties have been encountered in the use of two possible alternatives, namely the surface guided wave along a single wire and microstrip (parallel-strip transmission lines), and it seems unlikely that either of these methods can wholly replace the use of more conventional waveguides.

CORRESPONDENCE

POWER FACTOR PUZZLES

From C. R. BATES, *Associate Member*

Can any reader of the *Journal* suggest a definition of the power factor of a spot-welding machine? Demands are often made for the calculation or measurement of this, and even power-factor correction is asked for.

Surely the accepted conceptions of power factor cannot be applied, because such machines are highly inductive and are switched on for short periods only. In consequence the initial transient current surge is considerably distorted in shape and usually exceeds the value of full-load current. If the switch is closed at the instant of zero voltage, which is possible where mechanical contactors are used, the total flux built up in the core closely approaches twice the normal peak value. The high degree of saturation produced in the magnetic circuit permits the current to reach 8–10 times the full-load value. Even this can be exceeded if any residual flux exists in the core before switching takes place. P. Kemp, in his book, "Alternating Current Electrical Engineering,"* mentions that a current surge of 20–30 times the final value is possible when the iron is initially magnetized.

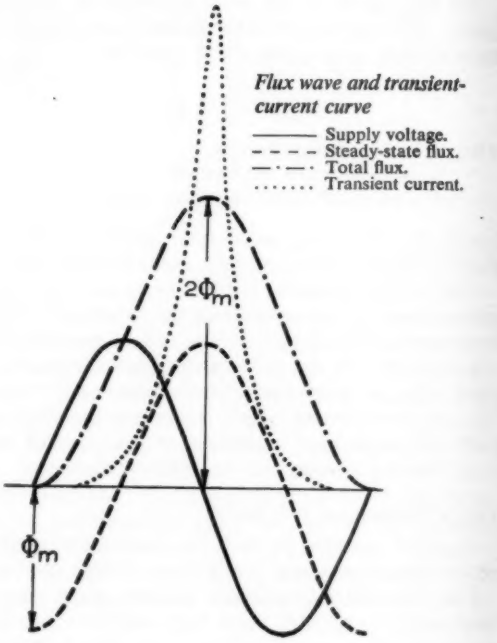
The theoretical conditions of flux and current for a welding machine switched on at zero voltage are shown in the diagram. If the energy is applied for one cycle only, the current consists of a surge of one polarity. The I^2R and eddy-current losses would tend to reduce the peak value of the current, and if the period of energization were prolonged the current would gradually be reduced to normal and become symmetrically placed about the zero line.

However, a spot-welding machine is usually energized for short periods, often for 5 cycles or even less. It is possible, therefore, for the current to consist of unidirectional pulses during this short period and thus leave a considerable amount of residual flux in the core. This could lead to the adverse conditions already mentioned if a further switching occurs soon afterwards, before the flux has had time to decay.

The transient disturbances are rapidly diminished during the first few cycles although the damping coefficient is not constant. The inductance of the transformer increases as the saturation decreases and the damping factor becomes smaller as the current decays to its normal value. Kemp has stated that the abnormal conditions can last as long as two minutes.

The current demand of a spot-welding machine switched by means of mechanical contactors is clearly very difficult to predict, and hence a welding machine is a most undesirable load to a supply authority. The true inconvenience is the transient-current demand, unpredictable in magnitude and polarity. Surely the power factor under conditions of continuous excitation bears no relation to this?

Correction of the steady-state power factor by means of condensers can only aggravate the matter, for the surge of charging current during each switching operation is of necessity high, with the discharged condenser representing a momentary short-circuit on the line. This surge is in addition to these drawn by the welding machine. Who benefits, therefore, when condensers are connected in parallel with a spot-welding machine?



Lastly, what is the power factor of a welding machine when it is fed from a controlled rectifier, as when ignitrons controlled by phase-shifted firing impulses are used? The current is now split into discrete pulses. The start of each pulse lags behind the voltage by an angle determined by the control. The conceptions of power factor are again meaningless under such conditions, whether considered by the ratio of power to apparent power or by the angle of lag. How therefore may such a load be judged, for the magnitude of the pulses is constant and may be accurately determined or adjusted—and, by the way, how may such a load be metered?

* Macmillan, 1953.

Mr. Bates is with Bates & Bates, Ltd.

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A list of papers published in the July issue of Part B of the Proceedings appears under "Contents of the Current Issues of the Proceedings" on page 493, and the serial number of each paper and the month of publication of a digest in the Journal are included. Synopses of both monographs and papers which will be published separately before the next issue of the Journal appear below, and unless otherwise stated, their date of publication is the same as this issue of the Journal. The monographs will be republished in Part C of the Proceedings, and the relevant Part for the republication of a paper is given after the serial number of the paper.

MONOGRAPHS

S. DEMCZYNSKI, Dipl.Eng.

The Correlation between Decay Time and Amplitude Response

MONOGRAPH No. 139 R

The object of the work described was to investigate the correlation existing between the decay time and the delay time of the indicial response on the one hand, and the bandwidth and peak values of the steady-state amplitude response and the slope of the phase response on the other.

The analysis is applied to five types of electrical networks and to some general classes of circuits, distinguished by the location of their poles in the p-plane. From these investigations the following results are obtained. (*a*) By interpolation of all numerical results obtained for the five types of networks, the statistical formulae embracing all of them are found. (*b*) Formulae giving the functional relationship between the decay time and the ratio f_3/f_6 are derived for each class of circuit considered. (*c*) The formula for the delay time, $t_l = [d\phi/d\omega]_{\omega=0}$, is checked for all five networks considered and is found to be valid for multi-stage, but not for single-stage, circuits.

A digest of the monograph will be published in Part B of the *Proceedings*.

ULRIK KRABBE, Ph.D.

The Residual Time-Constant of Self-Saturating (Auto-Excited) Transductors

MONOGRAPH No. 140 M

It is well known that the time-constant of a self-saturating transductor is determined mainly by the control winding, increase in the resistance of which will have the effect of reducing the time-constant, but that the time-constant is also influenced by the main winding, so that it is not strictly proportional to the conductivity of the control circuit.

This monograph deals with a theory for the effect of the main winding on the time-constant, and describes laboratory tests which confirm the theory; its consequences in cases where there is negative feedback from the output voltage are particularly discussed.

A digest of the monograph will be published in Part B of the *Proceedings*.

PAPERS

D. R. CHICK, M.Sc., B.Sc., and D. P. R. PETRIE, M.Sc.

An Electrostatic Particle Accelerator

PAPER No. 1869 M; PART B

A pressurized electrostatic generator has been designed to give as nearly as possible a uniform field in the dielectric medium, and the expected performance is calculated assuming that the insulating gas breaks down at 200 kV/cm.

The contribution of the generator and of a multi-section ion-accelerator tube is also described, and the performance of the machine both as a voltage generator and as an ion accelerator is reported. Novel methods of metering currents at the high-voltage electrode allow the behaviour of the generator in the presence of an ion beam to be analysed. The voltage stabilization of the accelerator and the stability of the main servo loops are discussed.

A beam analyser employing electrostatic deflection provides precise absolute measurement of the beam energy. Calibration points on the high-voltage scale at 874·7 and 2567 kV have been accurately determined. The peak performance is 3·8 MV with the 9 ft tube and 5·5 MV without the tube. Proton beams up to 3·25 MeV have been obtained with an energy resolution of 1 in 1200.

J. C. WEST, Ph.D., J. L. DOUCE, M.Sc., and R. K. LIVESLEY, Ph.D.

The Dual-Input Describing Function and its use in the Analysis of Non-Linear Feedback Systems

PAPER No. 1877 M; PART B

A new method is presented for the frequency-response analysis of non-linear elements. This involves evaluating the gain of one of the frequency components in passing through the non-linear element when the input to the element consists of two sinusoidal waves of differing amplitudes, phases and frequencies. A cubic characteristic is analysed fully as an example.

The paper describes the use of this method for analysing four different types of problem arising in feedback systems containing one simple-type element of amplitude non-linearity. The method can be considered as an extension of

the describing-function technique with a correspondingly wider field of application.

A. NEMET, Dr.Ing., F.Inst.P., and W. F. COX, B.Sc.

Intensification of the X-Ray Image in Industrial Radiology

PAPER NO. 1881 U; PART B

The paper deals with the application of the X-ray image intensifier tube in industrial fluoroscopy and radiography. It considers the factors governing resolution, i.e. brightness, blurring, contrast, and discusses the expected improvement in these due to the use of the image intensifier. Industrial fluoroscopy with this technique is compared with conventional fluoroscopy and contact radiography. Results are given of measurements obtained with DIN Penetrameters for steel and aluminium in the voltage range of 30–200 kV.

The conclusion is drawn that the image intensifier allows new applications of industrial fluoroscopy and miniature radiography due to the enhanced resolution which brings it near to contact radiography. It therefore permits more economical X-ray testing.

J. S. MØLLERHØJ, A. M. MORGAN, B.Sc.(Eng.), and C. T. W. SUTTON, M.Sc.(Eng.)

A Technical Assessment of Flat Pressure Cable

PAPER NO. 1884 S; PART A

The flat pressure cable has a fully-impregnated dielectric which is maintained under a positive pressure by means of a self-contained flexible membrane. After a review of the history of the development of the cable, the construction and the principles on which the cable is designed are described. The design of the accessories is dealt with, and this is followed by a description of the method of rating the cable. Electrical tests have proved that the cable is suitable for transmission at the highest voltages, and operational experience shows the cable to be completely satisfactory, both electrically and mechanically.

The cable has been used extensively in Europe for both terrestrial and submarine use, and to date 109 miles of 3-core cable have been installed. Future development of the cable with aluminium sheath and for transmission at direct voltages is discussed.

TECHNICAL PUBLICATIONS

BRITISH STANDARDS

The Secretary has been asked to draw attention to the following publications, copies of which can be obtained from the British Standards Institution, 2 Park Street, London, W.1. The prices given for each Standard are post free.

GLOSSARY OF ACOUSTICAL TERMS (B.S. 661: 1955). 6s.

This is a revision of a Standard first issued in 1936. The advance of acoustic techniques since that date has rendered necessary many changes in the contents and arrangement of the new edition, and about 80 new terms have been added (an increase of about 40%).

The main changes are: the enlargement of the section on recording and reproduction, particularly to cover the use of magnetic tape and wire, and the inclusion of a new section which mirrors the emergence of ultrasonics from laboratory demonstrations to varied industrial applications. A section on the subject of underwater sound, which in 1936 was mainly limited to the Naval application, has been included.

The first edition contained a number of musical terms (e.g. common chord, melody), which have now been deleted on the grounds that they are more appropriate to the art of music than to engineering and physics.

GLOSSARY OF TERMS USED IN RADIOLOGY (B.S. 2597: 1955). 10s.

This Standard is intended as an authoritative reference for medical and industrial radiologists and for general workers in radiology. It includes over 750 terms and definitions. Its four main sections cover: general terms and physics; sources of ionizing radiation; radiography and fluoroscopy; and radiotherapy and radiation protection. Its comprehensiveness may be appreciated from the fact that in it there are terms relating to such subjects as atomic physics, high-voltage generating equipment, X-ray tubes and their accessories, particle accelerators, diffraction analysis and medical isotopes. Where appropriate, quantitative values and symbols are given for the various terms. A complete alphabetical index is included.

GENERAL RECOMMENDATIONS FOR THE RADIOGRAPHIC EXAMINATION OF FUSION-WELDED JOINTS IN THICKNESSES OF STEEL UP TO 2 IN (B.S. 2600: 1955). 4s.

The work resulting in these recommendations was undertaken at the request of the British Welding Research Association. The increasing use of X-rays and gamma rays for the examination of welded joints in a wide variety of constructions has made it desirable to issue some general recommendations giving guidance on the application of these methods.

ELECTRIC COFFEE PERCOLATORS AND BREWERS FOR DOMESTIC USE (B.S. 2607: 1955). 3s.

The Standard specifies minimum safety requirements for heating elements for electric coffee apparatus of the immersion-, clamp- or separate-heater type, which are intended for operation on voltages exceeding 30 volts a.c. (r.m.s.) or 50 volts d.c., but not exceeding 250 volts a.c. or d.c. It includes clauses dealing with design and construction, heating elements, safety devices, means of connection and terminal arrangements. It has sections on marking and testing. Among the tests are those for stability, insulation, loading, temperature, endurance and automatic safety devices. An appendix deals with the method of measuring leakage current.

I.E.C. PUBLICATION

NO. 70–2. SPECIFICATION FOR CAPACITORS FOR POWER SYSTEMS, PART II.

Copies of the above I.E.C. publication may be obtained from the British Standards Institution, 2 Park Street, London, W.1, price 7s. 6d. each, post free.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

BOOKS

BOOTH, A. D. 518

Numerical Methods

Demy 8vo. pp. 195. London: Butterworth, 1955. 35*s*.

The purpose of this book is to give an explanation of the basic principles of numerical analysis, rather than details of actual calculations, and to show their application to programming for automatic computers.

BROWN, T. B. 621.38

Electronics

Roy. 8vo. pp. 545. London: Chapman and Hall, 1954. £3. *

A book for students containing descriptions of simple laboratory experiments and problems to be worked. Deals with the properties and fundamental applications of thermionic valves including gas-filled types, and with the physical processes taking place within the valves. The use of feedback, modulation processes and special uses of valves are discussed and there is a chapter on klystrons, magnetrons and travelling wave tubes.

BRUINSMA, A. H. 621.396.9

Remote Control by Radio

2nd ed. Demy 8vo. pp. 100. Eindhoven: Philips, 1954. 8*s*. 6*d*. *

A practical description of two systems of communication with a model ship; one a two-channel amplitude-modulated system giving limited control, the other an eight-channel pulse-modulated system permitting eight forms of intelligence to be transmitted simultaneously and independently. This edition describes modifications, particularly to the receivers, which have become possible with the availability of new battery valves. Germanium diodes have also been introduced in place of selenium rectifiers.

CAUER, W. 621.318.7

Theorie der Linearn Wechelstromschaltungen (Theory of linear alternating-current circuits)

Cr. 4to. pp. 769. Berlin: Akademie-Verlag, 1954. £4 2*s*. 3*d*.*

COBLENZ, A., AND OWENS, H. L. 621.314.63

Transistors: Theory and Applications

Roy. 8vo. pp. 313. London: McGraw-Hill, 1955. £2 2*s*. 6*d*. *

This book is based on a series of articles published in "Electronics" in 1953. It explains at some length, and in easily understood language, the modern physical theories which relate to the behaviour of semi-conductors and transistors. The uses of transistors and suitable circuits for them are described, typical values being given of components and performances. Manufacturing processes are described. The book will be reviewed in a future issue.

COOMBES, R. H. 631

Soil Warming by Electricity

Cr. 8vo. pp. 116. London: Cassell, 1955. 10*s*. 6*d*. *

A practical account of methods, dosages, results obtained and costs.

CORCORAN, G. F., AND PRICE, H. W. 621.38

Electronics

Roy. 8vo. pp. 459. London: Chapman and Hall, 1954. £2 16*s*. *

Deals with the physics of electron tubes and the operation of thermionic valves including their use as amplifiers and in feedback circuits. Transistors are also dealt with. Although each chapter contains a number of problems for the student to solve it is not an elementary book.

COTTON, H. (EDITOR) 622: 621.3

Electrical Equipment in Mines

Roy. 8vo. pp. 456. London: Newnes, 1955. £2 10*s*. *

Chapters by specialist authors cover power supplies, switchgear, cables, air-compressors, coal cutters, drills, haulage equipment, and signalling systems. The book will be reviewed in a future issue.

CROWTHER, J. G. 92 : 621

Six Great Inventors

Cr. 8vo. pp. 235. London: Hamish Hamilton, 1954. 10*s*. 6*d*. *

A very readable short account of the lives of Watt, Stephenson, Edison, Marconi, the Wright Brothers and Whittle.

FERGUSON, T. 621.33

Electric Railway Engineering

Med. 8vo. pp. 439. London: Macdonald and Evans, 1955. £2 17*s*. 6*d*.*

A book for engineers concerned with electrification projects rather than for the specialist designer of motors or other equipment. It deals with the principles and problems of complete systems, but gives information on the characteristics, performance, and ratings of machines and equipment which the traction engineer needs to know. There are no descriptions, illustrations or drawings of actual equipment which may become obsolescent, for the author has confined himself to discussing the important fundamentals of the subject. The book is reviewed on page 486.

GAY, C. M., AND OTHERS 697

Mechanical and Electrical Equipment for Buildings

3rd ed. Med. 8vo. pp. 564. London: Chapman and Hall, 1955. £3 8*s*. *

A simple treatment with examples, problems to be worked, and references to further reading. Contains a considerable amount of useful data on water supplies, sanitation, heating, air conditioning, acoustics, lighting, and American wiring practice.

GOTTER, G. 621.313.017

Erwärmung und Kühlung Elektrischer Maschinen (Heating and cooling of electrical machines)

Roy. 8vo. pp. 328. Berlin: Springer-Verlag, 1954. 34.50 marks.

HIGONNET, R., AND GRÉA, R. 621.316.3

Étude Logique des Circuits Électriques et des Systêmes Binaires (Logical study of electric circuits and binary systems)

Demy 4to. pp. 452. Paris: Éditions Berger-Levrault, 1955.

HUETER, T. F., AND BOLT, R. H. 534.321.9

Sonics. Techniques for the use of sound and ultrasound in engineering and science

Roy. 8vo. pp. 456. London: Chapman and Hall, 1955. £4.

Sonics implies the analysis, testing and processing of materials and products by the use of mechanical vibratory energy. The common principles are discussed, then the generation of sound by transducers, and finally applications. The book will be reviewed in a future issue.

KIVER, M. S. 621.396.029.6

Introduction to UHF Circuits and Components

Roy. 8vo. pp. 408. New York: Van Nostrand, 1955. £2 5*s*. •

A simple practical introduction to U.H.F. practice for those who have some familiarity with radio and audio-frequency equipment and circuits.

KOEHLER, G. 538.551

Circuits and Networks

Roy. 8vo. pp. 349. New York: Macmillan, 1955. £2 5*s*. 6*d*. •

An introductory treatment of networks, filters and circuits for students who are already familiar with alternating current theory and are not necessarily specializing in communications engineering.

MARTON, L. (EDITOR) 621.38

Advances in Electronics and Electron Physics. Vol. 6

Roy. 8vo. pp. 538. New York: Academic Press, 1954. £4 14*s*. 6*d*. •

The modification of the title of this series indicates that the scope of the papers is not restricted to electronics in the narrower sense of the word. Indeed the present volume contains papers on the physical properties of ferrites and on travelling-wave tubes.

MATHEWS, P. 621.316.9

Protective Current Transformers and Circuits

Med. 8vo. pp. 253. London: Chapman and Hall, 1955. 36*s*. •

Deals with the theory of current transformers for protective gear. Neither the voltage transformer nor the capacity voltage transformer for the same purpose are treated. Simple tests of the performance of installed transformers are described.

NOLL, E. M. 621.397

Television for Radiomen

3rd ed. Roy. 8vo. pp. 116. New York: Macmillan, 1955. £2 12*s*. 6*d*.•

A simple but detailed description of the principles of television transmission and reception. It refers to American practice.

RIDENOUR, L. N. (EDITOR) 53

Modern Physics for the Engineer

Roy. 8vo. pp. 499. London: McGraw-Hill, 1954. £2 16*s*. 6*d*. •

Based on lectures designed to give engineering specialists a broad outline of progress in other scientific fields. Discusses matter, radiation and the laws of their interaction; the physical laws of the universe, the earth and the atmosphere; new theories of communication; and computing machines. The book will be reviewed in a future issue.

SEMAT, H. 539

Introduction to Atomic and Nuclear Physics

3rd ed. Roy. 8vo. pp. 561. London: Chapman and Hall, 1954. £2 10*s*. •

This book for undergraduate students is divided into three parts. In the first the foundations common to atomic and nuclear physics are discussed, the second deals with the extra-nuclear structure of the atom, and the third deals at length with nuclear physics.

SHEA, R. F. 621.314.63

Transistor Audio Amplifiers

Roy. 8vo. pp. 219. London: Chapman and Hall, 1955. £2 12*s*. •

This is a practical work; it explains the fundamental principles of junction-type transistors in simple terms, and then considers them as four-terminal networks. Specifications for a variety of types now available are discussed and practical details of circuits using these types for pre-amplifiers and power amplifiers are given. The book will be reviewed in a future issue.

SHOEMAKER, R. W. 697

Radiant Heating

2nd ed. Roy. 8vo. pp. 346. London: McGraw-Hill, 1955. £2 10*s*. •

Discusses the comfort, convenience, efficiency and practicability of radiant heating, chiefly hot water or steam, in comparison with other conventional systems. Although written for the general reader it includes a considerable amount of data useful to the engineer.

SYKES, J. H. M. 621.3

A Guidebook to Electricity

Roy. 8vo. pp. 275. London: Hutchinson, 1955. 21*s*. •

An introduction to electricity and its applications written for the layman. Discussion of basic principles is kept to a minimum, and the description of generating plant, and commercial and domestic equipment is in the simplest terms.

THOMPSON, H. A. 538.551

Alternating-Current and Transient Circuit Analysis

Roy. 8vo. pp. 317. New York: McGraw-Hill, 1955. £2 10*s*. 6*d*.

A knowledge of differential and integral calculus is assumed in this introduction to steady-state and transient analysis. Discusses the steady-state, current, voltage, power and energy relations for sinusoidal wave shapes.

TSIEN, H. S. 621–52

Engineering Cybernetics

Roy. 8vo. pp. 289. London: McGraw-Hill, 1955. £2 6*s*. 6*d*. •

This is a mathematical study of the subject, including servo-mechanisms, considered as a science, for applications are not discussed. The reader is expected to be familiar with elementary mathematical analysis, complex integrations, variational calculus and differential equations. The book will be reviewed in a future issue.

WEISSFLOCH, A. 621.317.029.6

Schaltungstheorie und Messtechnik des Dezimeter- und Zentimeter wellengebietes (Circuit theory and measurement techniques in the decimetre- and centimetre-wave regions)

Cr. 4to. pp. 308. Basle: Birkhäuser Verlag, 1954. 33.50 Swiss francs.

WILSON, A. H. 537.31

The Theory of Metals

2nd ed. Cr. 4to. pp. 346. Cambridge: Cambridge University Press, 1954. £2 5*s*. •

Introduces the important physical principles of the modern theory of metals describing applications of them which are of wide interest. Gives a brief description of the conductivity of thin films, but surface effects, including the theory of semi-conducting rectifying contacts and the photo-electric effect are not included. The phenomena of superconductivity is not yet explainable, and so the chapter on it has been omitted from this edition.

OTHER PUBLICATIONS

BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION

Flexure Devices: a Bibliographical Survey, by P. J. Geary. Research Report M.18

Demy 8vo. pp. 44. Chislehurst: British Scientific Instrument Research Assoc., 1954. 10*s*. 6*d*.

CARPENTER, V. A.
The Heat Pump and District Heating (Modern Science Memoirs No. 32)
Demy 8vo. pp. 38. London: John Murray [1954]. 2*s*. *

ÉCOLE SUPERIEURE D'ÉLECTRICITÉ
Soixantenaire de l'École Superieure d'Électricité. May 1954
Cr. 4to. pp. 243. Paris: École Superieure d'Électricité, 1954.

INSTRUMENT SOCIETY OF AMERICA
Proceedings of the Instrument Society of America. Vol. 8, 1953.
Demy 4to. pp. 331. Pittsburgh: I.S.A., 1953. £4 5*s*.

LE POOLE, J. B.
Some Designs in Electron and Ion Optics
Roy. 8vo. pp. 96. Delft: Drukkerijen Hoogland en Waltman, 1954.

LOVELL, A. C. B., AND OTHERS
Radio Astronomy, by the Staff of the Jodrell Bank Experimental Station. (Royal Astronomical Society Occasional Notes, Vol. 3, No. 16, April, 1954)
8vo. pp. 79. London: Royal Astronomical Society, 1954. 6*s*. *

MEYRICK, N. L., AND ROMAN, G.
Ten Years of Semiconducting Materials and Transistors
Demy 4to. pp. 38. Cambridge: Pye Ltd., 1954.

MINISTRY OF FUEL AND POWER
A Programme of Nuclear Power
Roy. 8vo. pp. 22. London: H.M.S.O., 1955. 9*d*.

MINISTRY OF HEALTH
Mortality and Morbidity during the London Fog of December 1952: Report by a Committee of Departmental Officers and Expert Advisers appointed by the Minister of Health. (Reports on Public Health and Medical Subjects No. 95)
8vo., pp. 61. London: H.M.S.O., 1954. 2*s*. 6*d*.

MULTICORE SOLDERS LTD.
Soldering of Printed Circuits
Cr. 4to. pp. 4. Hemel Hempstead: Multicore Solders Ltd. [1954].

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL
Annual Report of the Conference on Electrical Insulation
Cr. 4to. pp. 67. Washington: National Academy of Sciences—National Research Council, 1955. $3.

NATIONAL BUREAU OF STANDARDS. UNITED STATES DEPARTMENT OF COMMERCE
Computer Development (SEAC and DYSEAC) at the National Bureau of Standards, Washington, D.C. (Circular 551)
Cr. 4to. pp. 146. Washington: U.S. Government Printing Office, 1955. $2.

NATIONAL BUREAU OF STANDARDS, UNITED STATES DEPARTMENT OF COMMERCE
Biennial Report 1953 and 1954. (Miscellaneous Publication 213)
8vo. pp. 162. Washington: U.S. Government Printing Office, 1954. 60 cents.

Table of Salvo Kill Probabilities for Square Targets
Cr. 4to. pp. 33. Washington: U.S. Government Printing Office, 1954. 30 cents.

Tables of Functions and of Zeros of Functions: Collected tables of the National Bureau of Standards Computation Laboratory. (Applied Mathematics Series 37)
Demy 4to. pp. 223. Washington: U.S. Government Printing Office, 1954. $2.25.

NATIONAL PHYSICAL LABORATORY
Engineering Dimensional Metrology. Proceedings of a Symposium at the National Physical Laboratory
2 vols. Cr. 4to. pp. 689. London: H.M.S.O., 1955. £2 5*s*.

NATIONAL RESEARCH DEVELOPMENT CORPORATION
Report and Statement of Accounts for the Year 1st July, 1953, to 30th June, 1954
8vo. pp. 21. London: H.M.S.O., 1955. 9*d*.

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD
Report and Accounts, 1st January, 1954, to 31st December, 1954
8vo. pp. 67. Edinburgh: H.M.S.O., 1955. 2*s*. 6*d*.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION
The Electricity Supply Industry in Europe. Trends in Economic Sectors
8vo. pp. 120. Paris: O.E.E.C., 1955. 10*s*.

SCHURE, A. (EDITOR)
R-C/R-L Time Constants
Med. 8vo. pp. 47. New York: Rider, 1954. 10*s*.

TENNESSEE VALLEY AUTHORITY
Design of T.V.A. Projects. Vol. 2. Electrical Design of Hydro Plants
Roy. 8vo. pp. 449. Washington: U.S. Government Printing Office, 1953. 21*s*. *

THORNE, F. W., AND WALSHAW, A. C.
Engineering Units and the Stroud Convention
8vo. pp. 29. London: Blackie, 1954. 3*s*. 6*d*.

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE
Prospects of Exporting Electric Power from Yugoslavia
Demy 4to. pp. 45. Geneva: United Nations, 1955. 3*s*. 9*d*.

ZINC DEVELOPMENT ASSOCIATION
Third International Conference on Hot Dip Galvanising held at Oxford, July 1954
Roy. 8vo. pp. 268. Oxford: Zinc Development Association, 1954. £2 2*s*.

SOME RECENT BOOKS

T. FERGUSON
ELECTRIC RAILWAY ENGINEERING
MACDONALD AND EVANS. 439 PP. £2 17s. 6D.

The title "Electric Railway Engineering" is perhaps a little misleading because the book omits detailed reference to track equipment with which the electric railway engineer must be familiar. The author's plea that track equipment forms a specialized study would be equally valid if applied to train equipment by specialist engineers in the other branch.

It is doubtful, so far as d.c. train equipment is concerned, whether any book so full and authoritative has ever been published before. So much so, that this work is one that no traction engineer can afford to ignore and that every student should possess. The first fourteen chapters are excellent, as indeed they could only be, because they result from the author's lifetime experience in a senior position in the electric traction industry. Chapter Three is of particular interest in showing the calculations necessary for the correct installation of axle-hung traction motors. Throughout the book the author rightly emphasizes the traffic aspect from which all design problems emanate. It is noteworthy too that he devotes considerable space to the mechanical features of rolling stock and attaches the same importance to the braking of trains (Chapter Four) as he does to their starting, a matter which is very often under-stressed when considering the operation of heavy freight trains over grades and some aspects of suburban working.

The author's remarkable flair for detail and consistently high standard of presentation is perhaps a challenge to the critic to expose omissions. But these are very few indeed. Cases in point are the reference to voltage drop, where use is made of figures based on new line work and rails at 60° F, whereas it is more usual to make allowance for part-worn rails and mean conductor-temperatures, the values of which may appreciably exceed 60° F, owing to current loading and exposure to the sun. Perhaps, too, the fact that voltage drop after single-unit substation temporary outage must not result in impairment of the effective operation of the brake compressors or exhausters, is a matter which deserved emphasis. The brief mention of interconnection of the line-equipment structures with an earth wire, in Chapter Twelve, is apt to leave the student with the impression that this is an optional alternative to bonding these to the track. No mention is made of the higher cost of an earth wire and that the question of its installation may be governed by track-circuit requirements, or, on d.c. electrifications, by the need for a return feeder, particularly on single-line sections.

In Chapter Fifteen the author leaves the field of his engineering experience to make an economic comparison between Diesel-electric and straight electric traction, and some would disagree that horse-power per ton of gross train-weight is the best basis for this comparison. In this chapter the omission of any allowance for the cost of alterations to ways and works (tunnels, bridges, signalling and telecommunications), which can easily, and often does, inflate the cost of electrification projects, not unnaturally results in a balance in favour of the electric locomotive. Having thus, perhaps unwittingly, discouraged the use of Diesel-electric locomotives in favour of straight-electric ones, the author in the next chapter seems to relegate them further in comparison with the gas-turbine type.

Chapter Seventeen compares different electrification systems; it is a little too concise, and once again the omission of the cost of ways and works alterations is apt to distort the comparisons. At the end of the following chapter, which discusses supply, the author states that each problem must be studied and solved to suit the conditions and that no two problems are likely to be the same. These words would form a fitting conclusion to all his helpful comparisons.

Having regard to the large mileage of a.c. railway electrification in America and on the Continent, the reader may think that insufficient space is devoted to these systems; particularly is it regretted that the work includes only a passing reference to railway electrification at the industrial frequency. In this matter the author seems to have missed an opportunity of bringing home the importance of basic d.c.-traction techniques to the engineer and student alike, because an industrial frequency system incorporating rectifier rolling-stock will inevitably lead both classes of reader to refer again to his absorbing and thorough study of the d.c.-motored electric train.

The book is printed in clear type; it contains many useful references and has a good index. The many diagrams and graphs are delightfully easy to read.

JAMES KENDALL
MICHAEL FARADAY: MAN OF SIMPLICITY
FABER AND FABER. 196 PP. 12s. 6D.

This biography of Michael Faraday should be read by everyone with any interest in matters electrical or chemical; but one should not begin to read it unless one has time to spare, for it is so absorbingly interesting that it cannot be laid down easily. The author, who is Professor of Chemistry in Edinburgh University, is evidently thoroughly steeped in the history not only of the scientific development of the period but also of the personalities concerned. He has recently written what may be regarded as a companion volume on Humphry Davy, to whom Faraday owed so much, and he maintains that, although Faraday was the greater man, without Davy there would have been no Faraday.

In the sixteen chapters into which the book is divided, Faraday's life is traced from his humble birth near Walworth in 1791, through his limited schooling and his service as an errand boy and bookbinder's apprentice, during which he attended some science lectures and showed such industry and intelligence that a customer at the bookshop gave him tickets for four of Humphry Davy's lectures at the Royal Institution, to the subsequent association that lasted to the end of Davy's life. The author describes in detail how Michael obtained the position of assistant to Davy and what doors it opened to him. He had not been long with Davy before he accompanied Sir Humphry and Lady Davy on a long Continental tour, during which he met Volta and other great scientists; this is the subject of the fourth chapter. A chapter entitled "The

Hare and the Tortoise" is devoted to the contrasting characters of Davy and Faraday, not only in their scientific work but in their married lives, for Davy married in haste and repented at leisure whereas, according to Tyndall, "there never existed a manlier, purer, steadier love" than Faraday's which "like a burning diamond, continued to shed for six and forty years its white and smokeless glow." It is surprising to read that when Faraday in later years remarked to Tyndall that "the greatest of all my great advantages is that I had a model to teach me what to avoid" he was referring to Sir Humphry Davy, who, the author says, "was always hungry for fame and could never tolerate a rival." He even opposed Faraday's election to the Royal Society. All this is described in a most interesting way in the three chapters on "The Superior Feelings of Philosophic Men." The two chapters entitled "The Great Sacrifice and What Came of it" describe the decision that he had to make in 1831, when his reputation as a chemist was such that he could easily have made an income of £5000 a year. As the author says, ye cannot serve Science and Mammon. "He could be rich and miserable, or he could be poor and happy; he chose the latter." So in September, 1831 he wrote "I am busy again in Electromagnetism and think I have got hold of a good thing, but can't say; it may be a weed instead of a fish." In the author's words, it was the biggest catch of the century.

On page 114 the author refers to William Sturgeon as a Woolwich electrician; this was in 1825 and one wonders what were the exact duties of an electrician in those days. On the same page we read that Henry wound with layer after layer of silk-covered copper wire "nine separate coils each sixty feet long with intervals between them along the horse-shoe." One cannot help wondering how long the horse-shoe really was.

The chapter "A Pawn in Politics" describes the political hubbub caused by the award to Faraday of a pension of £300 per annum by William IV in 1835. His subsequent researches at The Royal Institution are discussed in two chapters entitled "The Long, Long Trail" in which the human rather than the scientific point of view is taken, and his later activities, especially his lecturing, are described under the title "The Grand Old Boy." After a chapter on "His Beliefs and Disbeliefs" we come to "The End of the Road," which he reached in 1867 sitting peacefully in his study in the house at Hampton Court that the Queen had granted him in 1858.

The book is well produced and we noted only three printer's errors; on page 105 Faraday's name becomes "Micahel," on page 88 there is "suphuric acid" and on page 140 appears "lar" for "solar."

K. I. T. RICHARDSON
THE GYROSCOPE APPLIED
HUTCHINSON. 384 PP. 30s.

The book is not a treatise on the gyroscope itself, but, as its title implies, it describes various devices in modern engineering which depend for their functioning on the properties of the gyroscope. Since in a book of reasonable size a choice must be made between instruments which are designed to fulfil the same function, the reader should take careful note of the last paragraph of the introduction which states categorically that an instrument singled out for detailed description is not necessarily superior to its rivals.

The book is divided into five main sections: Fundamentals, Marine Applications, Aeronautical Applications, Military Applications, and Other Applications, of the Gyroscope. This is a great help to the reader who wishes to refer to any instrument in which he is particularly interested.

The section on fundamentals will appeal to anyone approaching the problem of gyroscopic motion for the first time, and the examples and illustrations are well chosen. It does not attempt to give the mathematical theory of the gyroscope, and the elementary mathematics that is introduced is not very helpful, since both the meanings of couple and torque and the vector notations of torque and angular momentum are confused.

The marine section describes the three best-known gyro-compasses, i.e. the Sperry, Brown and Anschütz, and discusses automatic steering of ships and ship stabilization. The description of the mechanical parts of all these devices is clear and is greatly helped by the excellent illustrations and diagrams. The description of the electrical circuits could be improved however, whilst the sudden introduction of terms like "Mag-slip" and "hunter" in the chapter on stabilizers will probably confuse many readers. It is unfortunate that the author should have found it necessary to justify the use of gyro-compasses by exaggerating the disadvantages of magnetic compasses, especially as his ideas on variation on page 52 are erroneous, whilst the deviation of a magnetic compass can of course be corrected.

The largest section of the book is that devoted to aeronautical applications. This might be expected since the navigation and control of aircraft have presented many new problems not encountered in motion on land or sea, and for many of these the gyroscope is the basis of the successful devices so far developed. Descriptions are given of the gyro-magnetic compasses now used in aircraft, though here a little more space might have been devoted to explaining the theory of the flux valve, to make its mode of operation clearer. There are also adequate paragraphs on artificial horizons, rate-of-turn indicators, slip indicators, etc. The chapter on automatic pilots is excellent, the description of the problems being very clear, and the account of approach procedure, whilst not very full, is interesting. Here again the diagrams and illustrations are very helpful.

In the section on military applications the author discusses bomb sights and gyro gun-sights, but to understand these properly would call for a much deeper understanding of gyroscopic theory and practice by the reader than has up to this point been assumed. The previous standard is, however, regained when the torpedo, and the control circuits for the V1 flying bomb and the V2 rocket, are described.

The section on other applications touches very lightly on such historical devices as the mono-rail car and the two-wheel motor car, and introduces a very modern instrument in the form of a gyro theodolite used in surveying German mines.

The mathematical appendix is quite simple and hardly necessary.

The book will prove most useful as a reference book to advanced students of engineering or physics, whose knowledge of gyroscopes is often purely theoretical, since it describes so clearly the practical applications of gyroscopes and the instruments which have been developed round them. It should also appeal to that wider class of readers with some scientific knowledge who are interested in the navigation and control of aircraft both with and without pilots.

The publishers are to be congratulated on the choice of type and the clear illustrations, and on the comparative freedom from misprints.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH JUNE, 1955

	No. of Contributors	£	s.	d.
£1000 and over	6	6000	0	0
£100 to <£1000	29	6386	3	0
£5 to <£100	737	8246	16	10
£2 to <£5	1799	5024	19	7
Under £2	17350	9217	8	3
		£34875	7	8

HONOURS AND DISTINCTIONS CONFERRED ON MEMBERS

THE QUEEN'S BIRTHDAY LIST

The names of the following members of The Institution were included in the list of Birthday Honours and Distinctions conferred by Her Majesty:

BARONET
Nelson, Sir George H. (*Member*).

KNIGHTHOOD
Bishop, Harold, C.B.E., B.Sc.(Eng.) (*Member*).

G.C.B.
Mountbatten of Burma, Admiral the Rt. Hon. the Earl, K.G., P.C., G.C.S.I., G.C.I.E., G.C.V.O., K.C.B., D.S.O., LL.D., D.C.L., D.Sc. (*Associate Member*).

C.B.E.
New, C. G. Morley (*Member*).
Sutherland, F. N., M.A. (*Member*).
Swift, R. E., B.Sc. (*Member*).

O.B.E.
Abate, Lt.-Col. A. T., R.E.M.E., B.Sc.(Eng.) (*Associate Member*).
Bird, J. W. G., M.B.E. (*Associate Member*).
Frugtniet, A. V. (*Associate Member*).
Hobgen, L. B. (*Member*).
Horgan, Lt.-Col. M. O., T.D. (*Member*).
Spagnoletti, P. H., B.A. (*Member*).
Toogood, H. F. (*Member*).
Williams, J. W. M. (*Member*).

M.B.E.
Addison, J. D. (*Member*).
Boyd, J. M., B.Sc.(Eng.) (*Associate Member*).
Cheel, H. G. (*Associate*).
Currall, Wing-Comdr. G. H., M.M. (*Associate Member*).
Ellis, H. D. McD., M.A. (*Member*).
Lambert, James E. (*Associate Member*).

I.S.O.
Waldron, E., M.B.E. (*Associate Member*).

SPECIALIZED SECTIONS: CHANGES IN SCOPES AND TITLES

The Council have recently reviewed the scope of the Specialized Sections with particular reference to the fields at present covered by the Technical Committees on Electrochemistry and Electrometallurgy, Telegraphs and Telephones, and Traction.

They have now decided that the work of the Electrochemistry and Electrometallurgy Committee and of the Traction Committee should be taken over by the Utilization Section Committee, and the work of the Telegraphs and Telephones Committee by the Radio Section Committee.

It has also been agreed that the title of the Measurements Section shall be altered to **Measurement and Control** Section in order to provide a more appropriate description of the ground it covers. Similarly, because of the increased scope of the Radio Section, its title will be changed to **Radio and Telecommunication** Section. These alterations will take effect from the 30th September, 1955.

ELECTION OF COUNCIL FOR THE YEAR 1955–56

The following were nominated for the vacancies which will occur in the offices of President, Vice-Presidents, Honorary Treasurer and Ordinary Members of Council on the 30th September next:

PRESIDENT SIR GEORGE H. NELSON, BART.

Vice-Presidents

T. E. GOLDUP, C.B.E.
SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C., LL.D., B.SC.

Honorary Treasurer THE RT. HON. THE VISCOUNT FALMOUTH

Ordinary Members of Council

Members

PROFESSOR H. E. M. BARLOW, PH.D., B.SC.(ENG.)
PROFESSOR J. GREIG, M.SC., PH.D.
H. H. MULLENS, B.SC.
C. M. COCK

Associate Members

D. MCDONALD, B.SC.
D. B. WELBOURN, M.A.

Companion G. L. WATES, J.P.

No other nominations were received. The Council have co-opted Mr. C. T. Melling, C.B.E., M.Sc. Tech., to fill the vacancy created by the election of Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C., LL.D., B.Sc., as a Vice-President before the completion of his term of office as an Ordinary Member of Council.

The constitution of the Council for next session will be as follows:

PRESIDENT SIR GEORGE H. NELSON, BART.

The Past-Presidents

Vice-Presidents

T. E. GOLDUP, C.B.E.
S. E. GOODALL, M.SC.(ENG.)
WILLIS JACKSON, D.SC., D.PHIL., F.R.S.
SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C., LL.D., B.SC.
SIR GORDON RADLEY, C.B.E., PH.D. (ENG.)

Honorary Treasurer THE RT. HON. THE VISCOUNT FALMOUTH

Ordinary Members of Council

Members

PROFESSOR H. E. M. BARLOW, PH.D., B.SC.(ENG.)
C. M. COCK
A. R. COOPER, M.ENG.
B. DONKIN, B.A.
PROFESSOR J. GREIG, M.SC., PH.D.
F. J. LANE, O.B.E., M.SC.
G. S. C. LUCAS, O.B.E.
C. T. MELLING, C.B.E., M.SC.TECH.
H. H. MULLENS, B.SC.
W. F. PARKER
R. L. SMITH-ROSE, C.B.E., D.SC., PH.D.
G. O. WATSON
E. L. E. WHEATCROFT, M.A.
R. T. B. WYNN, C.B.E., M.A.

Associate Members

A. T. CRAWFORD, B.SC.
D. MCDONALD, B.SC.
D. B. WELBOURN, M.A.
J. H. WESTCOTT, B.SC.(ENG.), PH.D.

Companion G. L. WATES, J.P.

Associate J. BENNETT

Chairmen and Past-Chairmen of Sections

W. BAMFORD, B.SC. (MEASUREMENT AND CONTROL)
*J. I. BERNARD, B.SC.TECH. (UTILIZATION)
L. DRUCQUER (SUPPLY)
D. B. HOGG, M.B.E., T.D. (UTILIZATION)
*C. W. OATLEY, M.A., M.SC. (RADIO AND TELECOMMUNICATION)
*J. D. PEATTIE, B.SC. (SUPPLY)
H. STANESBY (RADIO AND TELECOMMUNICATION)
*M. WHITEHEAD (MEASUREMENT AND CONTROL)

* Past-Chairmen.

Chairmen and Past-Chairmen of Local Centres

*MAJOR P. L. BARKER, B.SC. (NORTHERN IRELAND)
F. BARRELL (NORTH MIDLAND)
*A. R. BLANDFORD (SOUTH MIDLAND)
*PROFESSOR E. BRADSHAW, M.B.E., M.SC.TECH., PH.D. (NORTH-WESTERN)
*G. CATON (NORTH MIDLAND)
MAJOR E. N. CUNCLIFFE, B.SC.TECH. (NORTHERN IRELAND)
T. G. DASH, J.P. (WESTERN)
LIEUT. COL. H. S. DAVIDSON, T.D. (SOUTH MIDLAND)
*P. R. DUNN, B.SC. (MERSEY AND NORTH WALES)
L. H. FULLER, B.SC.(ENG.) (SOUTHERN)
*J. S. HASTIE, B.SC.(ENG.) (SCOTTISH)
*A. N. IRENS (WESTERN)
D. E. LAMBERT, B.SC.(ENG.) (NORTH-EASTERN)
*E. A. LOGAN, M.SC. (SOUTHERN)
PROFESSOR J. M. MEEK, D.ENG. (MERSEY AND NORTH WALES)
*G. W. B. MITCHELL, B.A. (NORTH-EASTERN)
*J. H. MITCHELL, B.SC., PH.D. (EAST MIDLAND)
F. R. C. ROBERTS (EAST MIDLAND)
G. V. SADLER (NORTH-WESTERN)
E. WILKINSON, PH.D., B.ENG. (SCOTTISH)

* Past-Chairmen.

ELECTION OF SECTION COMMITTEES FOR THE YEAR 1955–56

MEASUREMENT AND CONTROL SECTION

The following were nominated for the vacancies which will occur on the Committee of the Measurement and Control Section on the 30th September next:

Chairman W. BAMFORD, B.SC.

Vice-Chairman H. S. PETCH, B.SC.(ENG.)

Ordinary Members of Committee

J. BELL, M.SC. J. K. WEBB, M.SC.(ENG.), B.SC.TECH.
D. EDMUNDSON, B.SC.(ENG.)

No other nominations having been received, the constitution of the Committee for next session will be as follows:

Chairman W. BAMFORD, B.SC.

Vice-Chairmen

D. TAYLOR, M.SC., PH.D.
H. S. PETCH, B.SC.(ENG.)

Past-Chairmen

M. WHITEHEAD
J. F. COALES, O.B.E., M.A.

Ordinary Members of Committee

T. S. ANDREW
A. H. M. ARNOLD, PH.D., D.ENG.
J. BELL, M.SC.
PROF. F. BRAILSFORD, PH.D., B.SC. (ENG.)
W. CASSON
D. EDMUNDSON, B.SC.(ENG.)
C. G. GARTON
M. KAUFMANN
C. RYDER
PROF. C. HOLT SMITH, C.B.E., M.SC.
PROF. A. TUSTIN, M.SC.
J. K. WEBB, M.SC.(ENG.), B.SC.TECH.

Together with the following:
The President
A Representative of the Council
The Chairman of the Papers Committee
A Representative of each Local Measurement Group
A Representative of the National Physical Laboratory

RADIO AND TELECOMMUNICATION SECTION

The following were nominated for the vacancies which will occur on the Committee of the Radio and Telecommunication Section on the 30th September next:

Chairman H. STANESBY

Vice-Chairman J. S. MCPETRIE, PH.D., D.SC.

Ordinary Members of Committee

F. S. BARTON, C.B.E., M.A., B.SC.
A. J. BIGGS, PH.D., B.SC.
W. ROSS, M.A.
T. B. D. TERRONI, B.SC.
F. WILLIAMS, B.SC.

No other nominations having been received the constitution of the Committee for next session will be as follows:

Chairman H. STANESBY

Vice-Chairmen

R. C. G. WILLIAMS, PH.D., B.SC. (ENG.)
J. S. MCPETRIE, PH.D., D.SC.

Past-Chairmen

J. A. SMALE, C.B.E., A.F.C., B.SC.
C. W. OATLEY, M.A., M.SC.

Ordinary Members of Committee

PROF. H. E. M. BARLOW, PH.D., B.SC.(ENG.)
F. S. BARTON, C.B.E., M.A., B.SC.
A. J. BIGGS, PH.D., B.SC.
G. G. MACFARLANE, DR.ING., B.SC.
B. N. MACLARTY, O.B.E.
H. PAGE, M.SC.
N. C. ROBERTSON, C.M.G., M.B.E.
W. ROSS, M.A.
L. RUSHFORTH, M.B.E., B.SC.
T. B. D. TERRONI, B.SC.
A. M. THORNTON, B.SC.
F. WILLIAMS, B.SC.

Together with the following:
The President
A Representative of the Council
The Chairman of the Papers Committee
A Representative of each Local Radio and Telecommunication Group
Representatives of the Admiralty, the Air Ministry, Department of Scientific and Industrial Research, the Ministry of Supply, the Post Office and the War Office

SUPPLY SECTION

The following were nominated for the vacancies which will occur on the Committee of the Supply Section on the 30th September next:

Chairman (*a*) L. DRUCQUER

Vice-Chairmen

(*a*) P. J. RYLE, B.SC.(ENG.)
(*a*) D. P. SAYERS, B.SC.

Ordinary Members of Committee

(*a*) J. A. BROUGHALL, B.SC.
(*a*) O. J. CROMPTON, M.ENG.
(*a*) C. P. HOLDER, B.A.
(*b*) F. C. WALMSLEY

(*a*) Nominated by the Section Committee.
(*b*) Nominated by R. Baldwin, M. J. Dark, Professor W. J. John, B.Sc., W. H. L. Lythgoe and C. T. W. Sutton, M.Sc.(Eng.).

A ballot was therefore necessary, the result of which has been reported to the Chairman by the scrutineers appointed at the Section Committee held on 18th May, 1955.

The constitution of the Committee for next session will accordingly be as follows:

Chairman L. DRUCQUER

Vice-Chairmen

P. J. RYLE, B.SC.(ENG.)
PROF. M. G. SAY, PH.D., M.SC.
D. P. SAYERS, B.SC.

Past-Chairmen

J. D. PEATTIE, B.SC.
L. G. BRAZIER, PH.D., B.SC.

Ordinary Members of Committee

H. G. BELL, M.SC.TECH.
J. A. BROUGHALL, B.SC.
A. R. COOPER, M.ENG.
O. J. CROMPTON, M.ENG.
E. L. DAVEY, B.SC.(ENG.)
L. GOSLAND, B.SC.
C. P. HOLDER, B.A.
D. T. HOLLINGSWORTH
H. M. LACEY, B.SC.(ENG.)
J. R. MORTLOCK, PH.D., B.SC.(ENG.)
L. C. RICHARDS, B.SC.TECH.
L. H. WELCH, B.SC.(ENG.)

Together with the following:
The President
A Representative of the Council
The Chairman of the Papers Committee
A Representative of each Local Supply Group

UTILIZATION SECTION

The following were nominated for the vacancies which will occur on the Committee of the Utilization Section on the 30th September next:

Chairman D. B. HOGG, M.B.E., T.D.

Vice-Chairman J. VAUGHAN HARRIES

Ordinary Members of Committee

R. H. M. BARKHAM, B.SC.(ENG.) — T. E. HOUGHTON, M.ENG.
J. M. FERGUSON, B.SC.(ENG.) — H. G. TAYLOR, D.SC.(ENG.)

No other nominations having been received the constitution of the Committee for next session will be as follows:

Chairman D. B. HOGG, M.B.E., T.D.

Vice-Chairmen

H. J. GIBSON, B.SC. — J. VAUGHAN HARRIES

Past-Chairmen

J. I. BERNARD, B.SC.TECH. — B. L. METCALF, B.SC.(ENG.)

Ordinary Members of Committee

R. H. M. BARKHAM, B.SC.(ENG.) — A. J. KING, D.SC., M.SC.TECH.
G. H. DAVIDSON — A. H. MCQUEEN
S. ENGLISH, D.SC. — R. A. MARRYAT, B.SC.(ENG.)
J. M. FERGUSON, B.SC.(ENG.) — F. P. PHILLIPS, B.SC.(ENG.)
H. C. FOX — T. B. ROLLS, B.A.
T. E. HOUGHTON, M.ENG. — H. G. TAYLOR, D.SC.(ENG.)

Together with the following:
The President
A Representative of the Council
The Chairman of the Papers Committee
A Representative of each Local Utilization Group
Representatives of the Admiralty, the Air Ministry, the Ministry of Labour and National Service (Factory Department), the Ministry of Works, the Post Office and the War Office

STUDENTS' SECTIONS

The Council have approved a recommendation that the Students' Sections shall in future be known as **Graduates and Students** Sections. The new title comes into effect immediately.

STUDENTS' SUBSCRIPTIONS AND NATIONAL SERVICE

The Council have approved a recommendation that the subscription payable by Students during their periods of National Service should be reduced to 10s. 0d. per annum. This reduced subscription will be payable for two years from the 1st January following the Student member's call-up. Those wishing to take advantage of this dispensation should communicate with the Secretary, giving the date of their call-up.

The lower rate of subscription applies from the 1st January, 1955, but may be claimed by those called up in 1954. The ruling does not operate retrospectively before this date.

NOMINATIONS

BRITISH STANDARDS INSTITUTION COMMITTEES:

Illumination Industry Standards Committee (*LGE/—*)

The Council have nominated Mr. W. R. Stevens, B.Sc., Member, to serve as their representative on the above Committee in place of Professor H. Cotton, M.B.E., D.Sc., Member.

Technical Committee on Overhead Transmission Lines Material (*ELE/17*)

The Council have nominated Mr. P. J. Ryle, B.Sc.(Eng.), Member, to serve as their representative on the above Committee in place of Mr. H. W. Grimmitt, Member.

MEMBERS TRAVELLING TO AND FROM THE UNITED KINGDOM

Members visiting or taking up residence in the areas of any of the Oversea Branches, Oversea Committees or Joint Oversea Groups, which were listed on pages 397 and 398 of the June issue, are invited to apply to the Secretary of The Institution for a letter of introduction to the appropriate Honorary Secretary.

The Secretary will be obliged if members coming home from oversea will inform him of their addresses in this country, even if they do not desire a change of address to be recorded in the Institution register. This will enable him to advise such members of the various meetings, etc., of The Institution and its Local Centres, and, when occasion arises, to put them into touch with other members.

The Secretary will be pleased if those members from oversea who are able to visit the Institution premises will call upon him.

COMMUNICATIONS FROM OVERSEA MEMBERS

Oversea members are specially invited to submit, for publication in the *Proceedings*, written communications on papers read before The Institution or published in the *Proceedings* without being read. The contributor's country of residence will be indicated.

Copies of all papers read before The Institution are sent to each Oversea Representative of the Council for distribution to members likely to be in a position to submit communications.

WHITWORTH FOUNDATION AWARDS

Since the Whitworth Foundation awards were instituted there has been a large increase in scholarships from public funds, and this has had a marked effect on the entry for the Whitworth Scholarship examinations. At the same time there has been a growing need for more post-graduate awards in all branches of technology. To meet these changed conditions the Minister of Education has increased the number of Whitworth Senior Scholarships from two to three and has raised their value from £325 to £500 per annum. These awards, now to be known as Whitworth Fellowships, will be available for post-graduate work to holders of engineering degrees, and holders of Higher National Diplomas or Higher National Certificates in engineering with at least two distinctions. Candidates must also show that they have at least two years' practical engineering experience. There will also be a number of Whitworth Prizes of greater value than previously for meritorious candidates who do not qualify for a fellowship. The award of ordinary Whitworth Scholarships to engineering apprentices will be discontinued.

These new arrangements will take place in 1956, and further particulars can be obtained from "Rules and Conditions for the Award of Whitworth Fellowships and Prizes," published by Her Majesty's Stationery Office, or from the Ministry of Education (F.E.1.d.), Curzon Street, London, W.1.

POST-GRADUATE COURSE IN NUCLEAR TECHNOLOGY

A full-time post-graduate course, which is intended to provide an introduction to techniques and measurements used in nuclear physics, will be held at the Borough Polytechnic from September, 1955, to June, 1956. It is addressed to physics or electrical engineering graduates who propose to take up nuclear research, the design of nuclear instruments, work on radioisotope applications or reactor instrumentation. Further particulars and application forms for admission may be obtained from the Secretary, Borough Polytechnic, Borough Road, London, S.E.1.

THE JOURNAL REFERENCE SECTION *(pages 491-494)*

PATRON OF THE INSTITUTION: H.M. THE QUEEN

Council, 1954–55

PRESIDENT
J. ECCLES, C.B.E., B.Sc.

PAST-PRESIDENTS
SIR JAMES SWINBURNE, BART., F.R.S.
W. H. ECCLES, D.Sc., F.R.S.
THE RT. HON. THE EARL OF MOUNT EDGCUMBE, T.D.
J. M. DONALDSON, M.C.
PROFESSOR E. W. MARCHANT, D.Sc.
P. V. HUNTER, C.B.E.
H. T. YOUNG
SIR GEORGE LEE, O.B.E., M.C.
SIR ARTHUR P. M. FLEMING, C.B.E., D.Eng., LL.D.
J. R. BEARD, C.B.E., M.Sc.
SIR NOEL ASHBRIDGE, B.Sc.(Eng.)
COLONEL SIR A. STANLEY ANGWIN, K.B.E., D.S.O., M.C., T.D., D.Sc.(Eng.)
SIR HARRY RAILING, D.Eng.
P. DUNSHEATH, C.B.E., M.A., D.Sc.(Eng.)
SIR VINCENT Z. DE FERRANTI, M.C.
T. G. N. HALDANE, M.A.
PROFESSOR E. B. MOULLIN, M.A., Sc.D.
SIR ARCHIBALD J. GILL, B.Sc.(Eng.)
SIR JOHN HACKING
COLONEL B. H. LEESON, C.B.E., T.D.
SIR HAROLD BISHOP, C.B.E., B.Sc.(Eng.)

VICE-PRESIDENTS
T. E. GOLDUP, C.B.E.
S. E. GOODALL, M.Sc.(Eng.)
WILLIS JACKSON, D.Sc., D.Phil., F.R.S.
SIR GEORGE H. NELSON, BART.
SIR W. GORDON RADLEY, C.B.E., Ph.D.(Eng.)

HONORARY TREASURER
H. W. GRIMMITT.

Ordinary Members of Council
J. BENNETT
A. R. COOPER
A. T. CRAWFORD, B.Sc.
C. DANNATT, O.B.E., D.Sc.
B. DONKIN, B.A.
O. W. HUMPHREYS, B.Sc.
C. R. KING, C.B.E.
H. R. L. LAMONT, Ph.D., M.A. B.Sc.
F. J. LANE, O.B.E., M.Sc.
G. S. C. LUCAS, O.B.E.
G. LYON, M.Sc.(Eng.)
SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C., LL.D., B.Sc.
A. H. MUMFORD, O.B.E., B.Sc.(Eng.)
W. F. PARKER
PROFESSOR M. G. SAY, Ph.D., M.Sc.
R. L. SMITH-ROSE, C.B.E., D.Sc., Ph.D.
G. O. WATSON
J. H. WESTCOTT, B.Sc.(Eng.), Ph.D.
E. L. E. WHEATCROFT, M.A.
R. T. B. WYNN, C.B.E., M.A.

Chairmen and Past-Chairmen of Sections

Measurements
M. WHITEHEAD
*J. F. COALES, O.B.E., M.A.

Radio
C. W. OATLEY, M.A., M.Sc.
*J. A. SMALE, C.B.E., A.F.C., B.Sc.

Chairmen and Past-Chairmen of Sections —*contd.*

Supply
J. D. PEATTIE, B.Sc.
*L. G. BRAZIER, Ph.D., B.Sc.

Utilization
J. I. BERNARD, B.Sc.Tech.
*B. L. METCALF, B.Sc.(Eng.)

Chairmen and Past-Chairmen of Local Centres

East Midland Centre
J. H. MITCHELL, B.Sc., Ph.D.
*C. D. WILKINSON

Mersey and North Wales Centre
P. R. DUNN, B.Sc.
*T. COATES, M.Eng.

North Midland Centre
W. A. CROCKER
*G. CATON

North-Eastern Centre
G. W. B. MITCHELL, B.A.
*H. ESTHER, B.Eng.

North-Western Centre
PROFESSOR E. BRADSHAW, M.B.E., M.Sc.Tech., Ph.D.
*H. WEST

Northern Ireland Centre
MAJOR P. L. BARKER, B.Sc.
*J. R. W. MURLAND, B.Sc.(Eng.)

Scottish Centre
J. S. HASTIE, B.Sc.(Eng.)
*C. H. A. COLLYNS

South Midland Centre
A. R. BLANDFORD
*H. J. GIBSON, B.Sc.

Southern Centre
E. A. LOGAN, M.Sc.
*CMDR. C. V. ROBINSON, R.N., O.B.E.

Western Centre
A. N. IRENS
*J. VAUGHAN HARRIES

* *Past-Chairman.*

SECRETARY W. K. BRASHER, C.B.E., M.A., M.I.E.E.

Deputy Secretary F. JERVIS SMITH, M.I.E.E.

Assistant Secretary F. C. HARRIS

Editor-in-Chief G. E. WILLIAMS, B.Sc.(Eng.), M.I.E.E.

***Journal* Editor** C. T. RIVINGTON, M.A., A.M.I.E.E.

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 2nd May, 1955.

ELECTIONS

Associate Members

ARMSTRONG, Alfred Burton, B.Sc. (Eng.).
BOWDLER, George William, M.Sc.
CLAY, Gabriel Priestman, M.A.
HATTON, George, B.Sc.(Eng.).
HIGGINS, Ernest Douglas.
LEA, Charles Arthur, Lt. R.N.
MAPLE, May, (Mrs.).
REAL, William.
VIVIAN, Roy Harradine, B.Sc.

Associates

CROFT, Edwin.
FLOWERS, Cyril Hugh.
LORCH, Walter Ferdinand.
SCOTT, Donald.
WYAND, Sydney Juler.

TRANSFERS

Associate Member to Member

CASS-BEGGS, David Norman, M.Sc. Tech.
CATTAN, George.
DAVIDSON, George Douglas Graeme, B.Sc.(Eng.), M.Sc.Tech.
HORT, Edward Patrick.
LAMPERT, William Ernest Clement.
LEWIS, Kenneth.
MOODY, Wilfred.
MUIL, James.
NISBET, Thomas, B.Sc.
SEARLE, George, M.Sc.
STEPHENSON, Joseph Dodds, M.Sc., Ph.D.
SWIFT, Brian Mastin.
UNK, Jacob Marinus, Professor Ir.

Graduate to Associate Member

ARTHURSON, Alan, D.F.C.
BATEMAN, Ernest James.
BERRIDGE, Edward John.
BLAKE, William.
BLOCK, Nicolas Martin.
BLUNDELL, Alan John.
BUTTERWORTH, George Herbert, B.Sc.
COWAN, Matthew Reid, B.Sc.
DAVIS, James Henry.
DAVIS, Peter Arthur, B.Sc.(Eng.).
DIXON, Albert George.
DUNCOMBE, Leonard, B.Sc.(Eng.).
EVANS, Norman David, B.Sc.Tech.
FINDLAY, William, B.Sc.
FREW, Derek William, B.Sc.(Eng.).
GLEN, John, B.Sc.(Eng.).
GOLDING, John Winston.
GOW, Rupert Stanley, Capt., B.Sc.
GRUDGINGS, William Gordon, B.Sc.
GUNSON, Gerald, M.A.
HAMMETT, John Edwin Strickland.
HARP, Cyril.
HOLLAND, William Lesley.
INGRAM, Derek George Woodward, B.Sc.
INGRAM, George Michael.
JOHNS, George Shephard.
JOSLIN, Douglas Hector.
LEVITAN, Philip Max.
LIGHTFOOT, Leonard Arthur.
LITTLE, John Gilbert, B.Sc.(Eng.).
LODGE, Matthew Gordon.
MAYES, Philip Frederick, B.Sc.(Eng.).
MUIR, Allan Brian, B.E.
PIERSON, Malcolm Ramsay.
PURVIS, Robert Foster, B.Sc.
QUIGLEY, Roy Richard Edward, B.Sc.(Eng.).
RAE, Douglas Elliot, M.A.
RATCLIFFE, Peter Millen.
RAYNER, Grevile Hartree, B.A.
ROBINSON, John Alan, B.Sc.Tech.
RUSSEK, Roman Marian, B.Sc.(Eng.).
SAMSI, Ramesh Vithal.
SAUERMANN, Johann Daniel, B.Sc.
SLOMAN, Lionel Manuel.
SMITH, Derek Randall, M.A.
SUSANS, Donald Ernest.
TAYLOR, Keith.
THEOBALD, David Hugh.
TORBE, Juliusz.
TRAVIS, Peter Travis, B.Sc.(Eng.).
VEAL, Ashley James.
WATSON, Ernest Thomas.
WATSON, John, B.Sc.
WELLS, William John Alan, M.A.
WHITCROFT, John, B.Sc.
WONG, Stanley, B.E.
WRAY, Anthony Charles, M.A.

Student to Associate Member

LOCKETT, Eric Harry.
SOUL, Joseph, B.Sc.(Eng.).

The following elections and transfers approved by the Council are effective from the 19th May, 1955.

ELECTIONS

Graduates

ASHWOOD, Norman John.
BARBER, Mark Roy, B.Sc.
BARKER, William Rowland, B.Sc. (Eng.).
BLISS, John Jeremy, B.Sc.(Eng.).
BONIFACE, Santia, B.Sc.(Eng.).
BURGESS, John Anthony.
BURRIDGE, Frederick James.
CLARKE, John Alfred, B.Sc.
DAKE, Jacob Anton, B.Sc.
DAVIES, David Raymond, B.Sc. (Eng.).
EDGINGTON, Charles Thomas.
FAGBEMI, Olasupo, B.Sc.(Eng.).
GOLDBERG, John Louis, B.Sc.
GREENSLADE, James Frederick.
GRICE, Alexander Norman.
HASHEM, Abdullah Ibrahim, B.Sc. (Eng.).
HORSMAN, Norman.
HURST, Douglas Arthur.
JONES, James Robert.
LOGIE, Frank McLean, B.Sc.
MACPHERSON, Edward Barrie, B.E.
MILLER, George Edward.
MORGAN, Robert.
MORRISON, Robert Craig Don.
NESS, Alexander.
PARKER, Brian William, M.A.
RAMAMURTHI, Ramani.
THOMSON, James Norrie.
TRANTER, Albert John.
WILD, William John, B.E., B.Sc.
WILLIAMS, Thomas Edward, B.Sc.
WOODS, Jack.

Students

AKRAN, Claudius Degra Dehumo.
BAGH, Jens Otto.
BALL, Douglas Cedric, B.Sc.
BAUST, Norman Charles.
BRADLEY, Peter Anthony.
BURKE, James Francis.
CHAUDHRY, Mohammad Amin.
CORREIA, John Basil, B.E.
DOOTSON, Harold.
EDWARDS, John Anthony.
FAIRBAIRN, Frank Barrass.
GOLDSMITH, Ronald George.
GORMALLY, Frank.
HALL, John Leslie.
HAMELL, Anthony.
HAQ, Muhammad Ikramul.
HAZELL, Arthur Albert, B.Eng.
JONES, Frederick Peter, B.Sc.
KING, Ian Blair.
LEAR, Robert Frank.
LUFFMAN, Anthony.
MARTIN, Arthur George.
MASON, Brian.
MORRISON, Eric Harold.
PADWICK, Gordon Charles.
PHELPS, Griffith Emlyn.
RAMANUJAM, Chakrapani.
ROGERS, Alan John.
SEYMOUR, Derek.
SKWARA, Tadeusz.
SOPPET, Douglas Athol.
TUCKER, Ivor.
VINCENTI, Joseph Ellul.
WALSHE, Laurence Charles.
WATKIN, Thomas Elphin.
WILKINS, Graham Maitland.
WILKINSON, Norman.
YOUNG, Brian.

TRANSFERS

Student to Graduate

BELLIS, Frank Alan, B.Sc.
BIRD, Robert William, B.Sc.(Eng.).
BROUGH, Kenneth Cecil, B.Sc.
CHRISTOPHER, John William, B.Sc. (Eng.).
DAWS, Sailajananda, B.Sc.
FRASER, Charles George, B.Sc.
GARDNER, Peter Alan Edward.
GOWER, Dennis Noel, B.Sc.(Eng.).
HARRISON, Edward, B.Sc.
HAYTER, Derek John, B.Sc.(Eng.).
McKENZIE, Daniel, B.Sc.
McKENZIE, Duncan Robin, B.Sc. (Eng.).
MATTHEWS, David John.
PIZZEY, John.
ROBINSON, Trevor Howard.
SCOTT, Peter Noel.
SZOSTAK, Jerzy, B.Sc.(Eng.).
TURNER, Herbert William.
WILLIAMS, Brian Colin, B.Eng.

Local Honorary Treasurers of the Incorporated Benevolent Fund

East Midland Centre	*R. C. Woods*
Irish Branch	*A. Harkin, M.E.*
Mersey and North Wales Centre	*D. A. Picken*
North-Eastern Centre	*D. R. Parsons*
North Midland Centre	*J. G. Craven*
Sheffield Sub-Centre	
North-Western Centre	*W. E. Swale*
North Lancashire Sub-Centre	*G. K. Alston, B.Sc.(Eng.)*
Northern Ireland Centre	*G. H. Moir, J.P.*
Scottish Centre	*R. H. Dean, B.Sc.Tech.*
North Scotland Sub-Centre	*P. Philip*
South Midland Centre	*W. E. Clark*
Rugby Sub-Centre	*H. Orchard*
Southern Centre	*G. D. Arden*
Western Centre (Bristol)	*A. H. McQueen*
Western Centre (Cardiff)	*D. J. Thomas*
South-Western Sub-Centre	*W. E. Johnson*

Forthcoming Events

SEPTEMBER

8 *Thursday to* 12 *Monday* — Supply Section Summer Visit to Holland

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Contents of the Current Issues of the Proceedings

DATE OF JOURNAL DIGEST OR SPECIAL ARTICLE

PART A. POWER ENGINEERING (JUNE 1955)

Digest not yet published — E. B. FRANKLIN
Sealed Transformers (PAPER NO. 1674 S, JUNE 1954)

March 1955 — G. F. KENNEDY, M.A., M.I.MECH.E., AND P. H. MARGEN, B.SC.(ENG.)
The Economic Selection of Cooling Towers for Generating Stations (PAPER NO. 1706 S, SEPTEMBER 1954)

March 1955 — P. H. MARGEN, B.SC.(ENG.)
The Application of Friction/Heat-Transfer Correlations to Cooling-Tower Design (PAPER NO. 1705 S, AUGUST 1954)

Discussion on **Alternating-Current-Instrument Testing Equipment** before the North-Eastern Radio and Measurements Group

July 1955 — T. G. N. HALDANE, M.A., M.I.C.E., AND P. L. BLACKSTONE, T.D., M.A.
Problems of Hydro-Electric Design in Mixed Thermal–Hydro-Electric Systems (PAPER NO. 1749 S, NOVEMBER 1954)

Discussion on **Service Experience of the Effect of Corrosion on Steel-Cored-Aluminium Overhead-Line Conductors** before the North-Western Supply Group

Å. RUSCK. Lecture on **High-Voltage Transmission Developments in Sweden** before the Supply Section

Digest not yet published — A. MANDL, D.SC.TECH.
Single-Phase 50 c/s A.C. Traction using a Rectifier (PAPER NO. 1788)

July 1955 — D. B. REAY, M.SC.(ENG.)
Distortion of Turbo-Alternator Rotor Windings through Thermal Stress (PAPER NO. 1813 S)

Written discussion on **The Propagation of Surge Voltages through High-Speed Turbo-Alternators with Single-Conductor Windings**

Written discussion on **The Transient Behaviour of Ladder Networks of the Type representing Transformer and Machine Windings**

April 1955 — H. W. WOLFF, B.SC., AND T. G. F. ATHERTON, B.A.
Design, Performance and Application of Miniature Circuit-Breakers (PAPER NO. 1745 U, DECEMBER 1954)

Discussion on **The Logical Approach to the Problems of Space Warming by Electricity** before the East Midland Centre, the North-Western Utilization Group, the Mersey and North Wales Centre, the Western Centre, the North Midland Utilization Group, the Southern Centre, the South-East Scotland Sub-Centre, the North Staffordshire Sub-Centre, the Northern Ireland Centre and the South-Western Sub-Centre

Discussion on **Inherent Current, Voltage and Speed Control in Dynamo-Electric Machinery** before the North-Western Utilization Group, a joint meeting with The Institution of Engineers, Australia, the South Midland Supply and Utilization Group, the Mersey and North Wales Centre, the Western Utilization Group and the East Midland Centre

Discussion on **The Testing and Specification of Bushings in Relation to Service Conditions** before the Southern Centre, the Western Centre, the North-Western Supply Group, the North-Eastern Centre, the North Midland Centre and the Northern Ireland Centre

Discussion on **Telemetering for System Operation** before the Mersey and North Wales Centre, the Western Centre and the East Midland Centre

Written discussion on **Magnetic Measurement of Mechanical Hardness**

Discussion on **Resistance Heating of Mild-Steel Containers at Power Frequencies** before the Sheffield Sub-Centre

Discussion on **The Royal Festival Hall: Electrical Installation** before the North Midland Utilization Group, the South Midland Supply and Utilization Group and the South-Western Sub-Centre

Digests of Institution Monographs:

P. HAMMOND, M.A. **Leakage Flux and Surface Polarity in Iron Ring Stampings** (MONOGRAPH NO. 116, JANUARY 1955)

J. W. LYNN, M.SC. **The Tensor Equations of Electrical Machines** (MONOGRAPH NO. 117 S, JANUARY 1955)

E. UHLMANN, DR.-ING.
Alternating Voltage, Direct-Voltage Regulation Drop and Power Factor of Convertor Stations operating on A.C. Systems of Finite Short-Circuit Capacity (MONOGRAPH NO. 131 S, MAY 1955)

PART B. RADIO AND ELECTRONIC ENGINEERING (JULY 1955)

Digest not yet published — R. S. WEBLEY, B.SC., H. G. LUBSZYNSKI, DR.-ING., F.INST.P., AND J. A. LODGE, B.SC.
Some Half-Tone Charge Storage Tubes (PAPER NO. 1883 R)

Discussion on **An Analogue Computer for Use in the Design of Servo Systems** before the South-East Scotland Sub-Centre

Contents of the Current Issues of the Proceedings *(contd.)*

DATE OF JOURNAL DIGEST OR SPECIAL ARTICLE

PART B. RADIO AND ELECTRONIC ENGINEERING (JULY 1955) *(contd.)*

Digest not yet published
G. B. B. CHAPLIN, M.SC., PH.D., R. E. HAYES, B.SC., AND A. R. OWENS, B.SC.
A Transistor Digital Fast Multiplier with Magnetostrictive Storage (PAPER NO. 1858 R)

Discussion on **Determination of the Static and Dynamic Elastic Properties of Resilient Materials** before the North-Western Measurements Group and the North-Eastern Radio and Measurements Group

April 1955
D. EDMUNDSON, B.SC.(ENG.)
Electrical and Magnetic Measurements in an Electrical Engineering Factory (PAPER NO. 1703 M, SEPTEMBER 1954)

Digest not yet published
E. D. DANIEL, M.A.
A Flux-Sensitive Reproducing Head for Magnetic Recording Systems (PAPER NO. 1856 R)

Discussion on **Some Applications of the Electrolytic Tank to Engineering Design Problems** before the North-Eastern Radio and Measurements Group, the North-Western Centre, and the South-West Scotland Sub-Centre

April 1955
R. W. PALMER
Maintenance Principles for Automatic Telephone Exchange Plant (PAPER NO. 1777, JANUARY 1955)

Digest not yet published
S. DEB
Amplification Factors and Mutual Conductance of a Beam Power Valve (PAPER NO. 1835 R)

Digest not yet published
G. L. CONNON, B.SC.(ENG.)
Carrier-Leak in Rectifier Modulators of the Shunt Type (PAPER NO. 1803 R)

Digest not yet published
BENGHT A. DAHLMAN
A Double-Ground-Plane Strip-Line System for Microwaves (PAPER NO. 1852 R)

Digest not yet published
A. F. HARVEY, D.PHIL., B.SC.(ENG.)
Standard Waveguides and Couplings for Microwave Equipment (PAPER NO. 1807 R)

Digest not yet published
A. E. KARBOWIAK, PH.D., B.SC.(ENG.)
On the Surface Impedance of a Corrugated Waveguide (PAPER NO. 1882 R)

Digest not yet published
R. NAISMITH
An Improved Chart for Ionospheric Forecasting in the British Zone (PAPER NO. 1855 R)

April 1955
J. K. S. JOWETT, B.SC.(ENG.), AND G. O. EVANS, B.SC.
A Study of Commercial Time Lost on Transatlantic Radio Circuits due to Disturbed Ionospheric Conditions (PAPER NO. 1708 R, OCTOBER 1954)

April 1955
A. M. HUMBY, C. M. MINNIS, M.SC., F.INST.P., AND R. J. HITCHCOCK, B.A.
Performance Characteristics of High-Frequency Radiotelegraph Circuits (PAPER NO. 1787 R, JANUARY 1955)

May 1955
K. C. BOWEN, B.A.
Sources of Error in U-Adcock High-Frequency Direction-Finding (PAPER NO. 1810 R, FEBRUARY 1955)

May 1955
E. N. BRAMLEY, M.SC.
Some Aspects of the Rapid Directional Fluctuations of Short Radio Waves reflected at the Ionosphere (PAPER NO. 1713 R, AUGUST 1954)

May 1955
W. C. BAIN, M.A., B.SC., PH.D.
On the Rapidity of Fluctuations in Continuous-Wave Radio Bearings at High Frequencies (PAPER NO. 1715 R, OCTOBER 1954)

May 1955
E. N. BRAMLEY, M.SC.
Some Comparative Directional Measurements on Short Radio Waves over Different Transmission Paths (PAPER NO. 1716 R, SEPTEMBER 1954)

Digests of Institution Monographs:

A. TALBOT, M.A., PH.D.
Some Fundamental Properties of Networks without Mutual Inductance (MONOGRAPH NO. 118 R, JANUARY 1955)

P. HAMMOND, M.A.
Leakage Flux and Surface Polarity in Iron Ring Stampings (MONOGRAPH NO. 116, JANUARY 1955)

D. G. TUCKER, D.SC., PH.D.
Signal/Noise Performance of Multiplier (or Correlation) and Addition (or Integrating) Types of Detector (MONOGRAPH NO. 120 R, FEBRUARY 1955)

H. V. SHURMER, M.SC., PH.D.
A Direct-Reading Waveguide Standing-Wave Detector for Use at Low Power Levels (MONOGRAPH NO. 119 R, JANUARY 1955)

K. W. H. FOULDS, PH.D., B.SC.(ENG.)
Resonant-Cavity Measurements of the Relative Permittivity of a D.C. Discharge (MONOGRAPH NO. 122 M, MARCH 1955)

D. MCDONNELL AND W. R. PERKINS, B.SC.
The Stability and Time Response of Fast Operating Closed-Loop Pulsed Radar Circuits (MONOGRAPH NO. 121 R, MARCH 1955)

PART C. MONOGRAPHS (MARCH 1955)

See March *Journal*, page 208.